# New Scientist

**WEEKLY** 17 June 2023

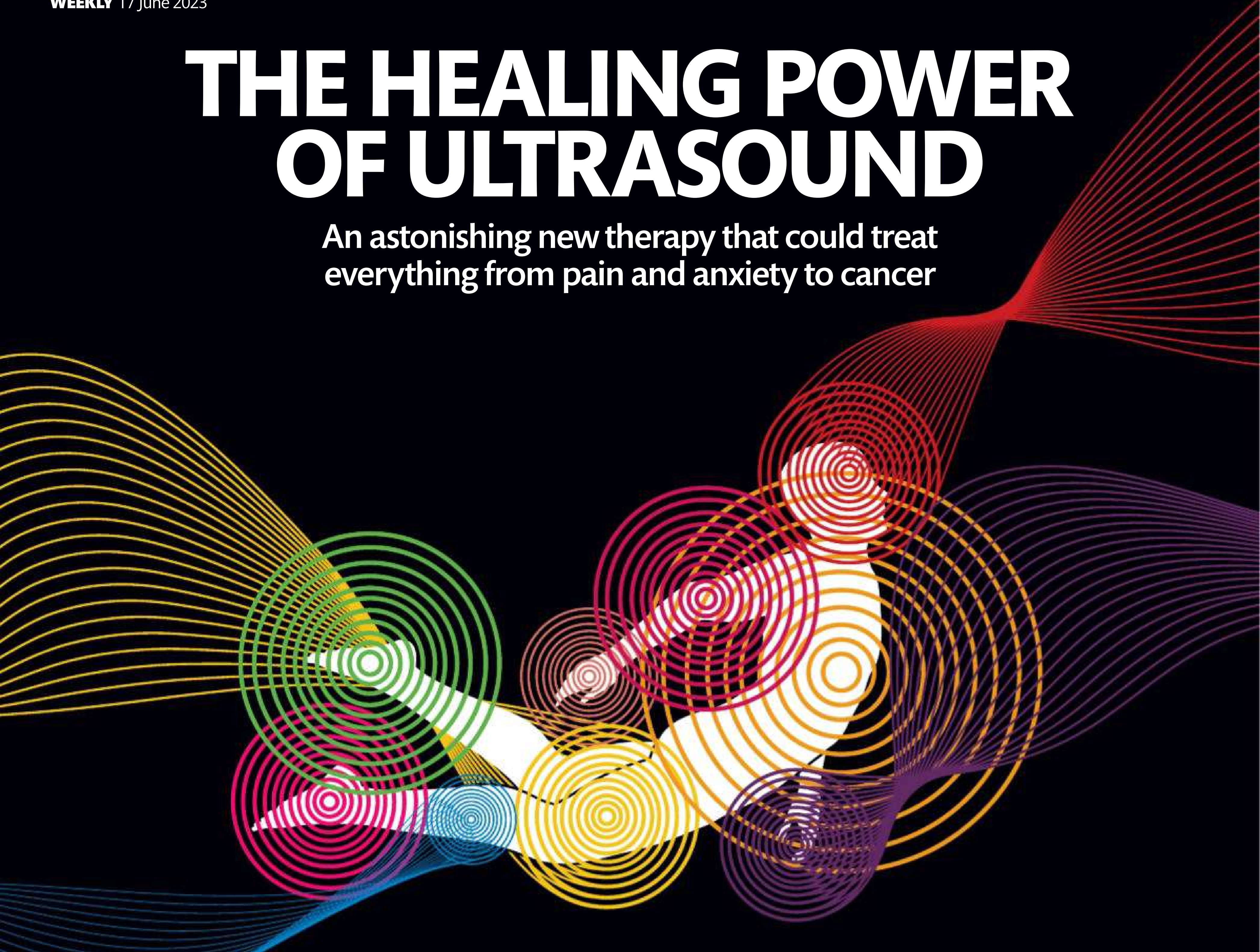
WE FINALLY KNOW WHAT CAUSES MORNING SICKNESS

THE DRY LAKE PREVENTING CALIFORNIA'S NEXT MAJOR QUAKE

HAVE WE FOUND THE EARLIEST SIGNS OF COMPLEX LIFE?

## THE HEALING POWER OF ULTRASOUND

An astonishing new therapy that could treat everything from pain and anxiety to cancer



## IMPOSSIBLE GALAXIES

The JWST images upending our best theory of the cosmos

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New Scientist

THE HEALING POWER OF ULTRASOUND

IMPOSSIBLE GALAXIES

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# Elsewhere on New Scientist

## Virtual event

### Ageless: How science can help us live longer and better

What if we could reverse ageing to prevent conditions including Alzheimer's? Join computational biologist Andrew Steele to explore the efforts to do just that, and pick up some tips on how to slow down the ageing process in your body. Watch this free subscriber-only event online at 6pm BST/1pm EDT on 22 August.

**newscientist.com/benefits**

## Tour

### Total Solar Eclipse 2024: Albuquerque to San Antonio, US

Experience a stunning total solar eclipse in Texas and explore the scientific heritage of the southern US. Accompanied by *New Scientist* features editor Abigail Beall, you will visit observatories including the Very Large Array before travelling to a secluded ranch to view the eclipse. The 10-day tour begins on 1 April 2024. Tickets are £5549.

**newscientist.com/tours**

## Podcast

### Weekly

*Homo naledi*, an ancient human with a tiny brain, may have buried its dead – the team examines the evidence. There is also a report from New York about extreme air pollution in North America from wild fires. Plus, in the CultureLab podcast, culture and comment editor Alison Flood discusses an opera about the legacy of the "Irish giant" Charles Byrne.

**newscientist.com/nspod**

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**Question time** Can you slow down the ageing process in your body?

XINHUA/ALAMY

**If bones could talk** *Homo naledi* may have buried its dead

## Video

### Instant heart valves

On our YouTube channel this week, there is footage of an artificial heart valve that was fashioned from a liquid polymer in a few minutes – rather than the weeks or months usually required. When implanted in sheep, the valve effectively controlled blood flow. Eventually, the new technology may be used in humans, particularly to help children with heart valve disease.

**youtube.com/newscientist**

## Newsletter

### Launchpad

Have we been visited by intelligent aliens? Space reporter Leah Crane considers the question following a meeting of NASA's task force on unidentified anomalous phenomena (UAPs). It is doubtful we have had any visitors, though, as the universe is vast and human civilisation is only a few thousand years old.

**newscientist.com/launchpad**

Newsletter

> **"When it comes to actually looking for alien life, maybe we should stick to microbes"**

## Essential guide

Our planet still holds many secrets. How did Earth form? How is it changing with global warming? And are there other Earth-like worlds out there? This *New Scientist Essential Guide* offers answers. Available to download in the *New Scientist* app or to purchase in print from our shop.

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# Living up to the hype

## The James Webb Space Telescope has already transformed cosmology

A REVOLUTION in our understanding of the universe is coming. Like so many previous upheavals, it is currently unclear exactly what the trigger might be. But what is clear, almost a year on from the release of its first images, is that the James Webb Space Telescope's observations of far distant galaxies are the most likely source of transformational insights.

Yes, this is precisely what JWST was designed for. But it is worth remembering that before its launch, which came years later than planned and after the budget had spiralled out of control, some astronomers were privately speculating on what progress their science could have made if only JWST's gargantuan budget had been apportioned to a series of smaller missions.

Now, there can be no doubt that the $10 billion telescope has delivered on its game-changing promise. It has peered inside nearby star-forming regions, revealed stars in their death throes and successfully probed the atmospheric composition of planets far beyond our solar system. But it is the images of the very distant universe that contain the seeds of cosmological revolution.

> "There can be no doubt that the $10 billion telescope has delivered on its promise"

Astronomers are now able to analyse in unprecedented detail galaxies dating from just a few hundred million years after the big bang. As we explore in our feature on page 36, what they are finding is casting our best explanations for how the universe evolved into doubt. That story is full of twists and turns. But even if the current model of cosmic evolution escapes this latest challenge, there will be more to come as JWST's data haul continues.

A single image recently captured by the telescope shows 45,000 galaxies, 700 of which are brand new discoveries and some of the youngest galaxies ever seen. Any of these has the potential to add to the conundrum facing cosmologists.

Either we don't understand how galaxies form or we don't understand how the universe came to be the way it is – or both. Not bad for a telescope that some thought was a colossal waste of money. ■

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© 2023 New Scientist Ltd, England. New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

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# News

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**Make some noise**
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Space flight

## SpaceX Dragon breaks records

Dragon cargo capsules have now made it to the International Space Station (ISS) 38 times, more than NASA's space shuttles did. The most recent robotic Dragon 2 mission (pictured approaching the ISS) arrived on 6 June. SpaceX says its reusable Dragon 2 fleet has now logged 1324 days in orbit, also surpassing the space shuttles' cumulative flight time.

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**Health**

# Cause of morning sickness found

A hormone called GDF15 has been identified as the cause of nausea in pregnancy, which should lead to ways to prevent and treat the most severe cases, finds **Michael Le Page**

AN EXCESS level of a hormone called GDF15 is the main cause of pregnancy sickness, including the most severe cases, known as hyperemesis gravidarum. The evidence for this has been growing for the past few years and now a study combining multiple lines of evidence should settle the issue.

Crucially, the study also shows that women's sensitivity to GDF15 depends on how much their bodies produce before pregnancy. The findings suggest that if those with a high risk of hyperemesis gravidarum, which can be life-threatening, are given extra GDF15 before they become pregnant, it may prevent the condition.

KLAUS VEDFELT/GETTY IMAGES

Around two-thirds of women experience nausea and vomiting during pregnancy. Despite being widely known as morning sickness, it can happen at any time of day. It usually declines after the first three months, yet in about 1 in 50 pregnancies it can result in hyperemesis gravidarum, in which it is impossible to eat and drink normally.

GDF15 was first discovered in 1997, but it wasn't until 2017 that we found out it binds to specific receptors in the brain and triggers nausea and vomiting. It is normally present in low amounts in the blood, but stresses such as illnesses can increase its level.

That led Stephen O'Rahilly at the University of Cambridge to propose that GDF15 evolved to trigger food aversion in response to, say, poisoning and that it contributes to morning sickness. Sure enough, his team found higher levels in women with more pregnancy sickness.

Then, in 2018, Marlena Fejzo at the University of Southern California, Los Angeles, and her colleagues found that the risk of hyperemesis gravidarum was associated with certain variants in the gene for GDF15.

Now, a team including Fejzo and O'Rahilly has released a study that hasn't yet been peer-reviewed describing additional evidence. The study didn't look at transgender men or non-binary people.

The researchers first found that GDF15 levels were significantly higher in about 60 women with hyperemesis gravidarum than in 60 pregnant women who reported little nausea and vomiting.

By looking at women and fetuses that produce different variants of GDF15, they found that most extra GDF15 in pregnant women comes from the fetus.

> **"Women's sensitivity to GDF15 depends on how much their bodies produce before pregnancy"**

The researchers also discovered that several genetic variants linked to a higher risk of hyperemesis gravidarum have the effect of lowering GDF15 levels in those who aren't pregnant. They then analysed data from a previous study of 18,000 people and found that higher levels of GDF15 when not pregnant reduce the risk of the condition.

> **Around two-thirds of women experience nausea and vomiting during pregnancy**

The explanation may be that women with higher blood levels of GDF15 before pregnancy become desensitised to the hormone and are therefore less affected by raised levels in pregnancy, suggest the researchers.

This desensitisation effect could explain why morning sickness usually recedes after the first trimester. It might also explain why women who smoke before pregnancy, which raises GDF15 levels, are less likely to get hyperemesis gravidarum.

To test the desensitisation idea, the researchers injected male and female mice with a long-lasting form of GDF15 and others with a placebo. Three days later, all the mice were given a large dose of GDF15. Those initially given the placebo ate less and lost weight, but those with prior exposure were less affected.

Because the blood condition beta thalassaemia is known to raise GDF15 levels, the team also did a survey of 20 women with this condition who had given birth and 20 matched controls. They found just one woman with beta thalassaemia who reported nausea and vomiting during pregnancy, compared with 13 of the women in the control group (bioRxiv, doi.org/kd5k).

"The work by Fejzo and colleagues has provided compelling evidence that alterations in GDF15 may be linked to hyperemesis gravidarum," says Sumona Saha at the University of Wisconsin-Madison.

The findings suggest that hyperemesis gravidarum could be prevented by boosting GDF15 levels before pregnancy.

They also suggest that lowering GDF15 levels during pregnancy will reduce nausea. At least four companies are developing antibodies that bind to GDF15 to help treat other conditions where the hormone causes nausea, vomiting and weight loss.

For instance, a 2020 study showed that an antibody that mops up GDF15 reduces vomiting in monkeys. This is already being tested in early-stage clinical trials, a spokesperson for pharmaceutical firm Pfizer told *New Scientist*.

In the 1950s, thalidomide was used to treat morning sickness before it was found to cause serious congenital conditions.

Fejzo, O'Rahilly and their colleagues don't think anti-GDF15 antibodies will harm developing fetuses, but note that it might be safest to modify antibodies to prevent them crossing the placenta into the fetus. "Since the tragedy of thalidomide, concerns about safety have understandably been very prominent," the team writes. ▮

Zoology

## Harbour seals may learn songs years before singing them

Corryn Wetzel

MALE harbour seals use complex vocalisations to woo females and it appears they learn the songs while they are still babies.

Social mammals like naked mole rats learn calls and sounds from close contact with other members of their species. Harbour seals (*Phoca vitulina*) spend their lives alone, apart from a few weeks of puppyhood with their mothers, says Diandra Düngen at the Max Planck Institute for Psycholinguistics in the Netherlands.

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Harbour seals have a few weeks with their mothers, then spend years living alone

Female harbour seals never use vocalisations. The males, when a few years old, perform complex vocalisations for female affection. Earlier work has suggested that these calls aren't innate.

To investigate how the seals might learn their songs, Düngen and her colleagues combed existing research. This included a case study of Hoover, an orphaned pup that was raised by humans during his first few weeks of life.

Hoover ended up in an aquarium, where he later stunned staff with his singing efforts, imitating phrases he heard as a young pup, like his own name, "Hello, there!" and "Come over here!".

The researchers found that harbour seal mothers give birth before males start singing, and the peak singing activity coincides with the pups' first forages at sea (*Ethology*, doi.org/kd55). This leads them to propose that the pups have a sensitive phase, at around 3 to 7 weeks old, when they learn their songs. ▮

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Microbiome

# Gut bacteria could affect your intelligence test scores

Carissa Wong

THE levels of certain bacteria in our guts have now been linked to varying degrees of intelligence, as determined by scores on mathematical and verbal tests. But whether people could take supplements to change their gut bacteria and improve these skills is unclear.

Several studies have linked the mix of bacteria in the gut, or the gut microbiome, to memory or the ability to learn. But this could be down to people's level of education influencing their food choices, which then affects the microbiome.

To understand if gut bacteria directly influence markers of intelligence or if there is just a correlation between the two, Tie-Lin Yang at Xi'an Jiaotong University in China and his colleagues analysed the potentially causal effects of two groups of gut bacteria, called *Fusicatenibacter* and *Oxalobacter*. They tried a kind of analysis called Mendelian randomisation, which uses the random genetic variation that occurs among people as a stand-in for the levels of the bacteria that may otherwise be assigned in a traditional randomised controlled trial.

The researchers analysed microbiome and genome data previously collected from more than 18,000 people. They pinpointed 10 genetic variants that have previously been linked to levels of *Oxalobacter* bacteria in people's guts and 14 genetic variants linked to *Fusicatenibacter*. They also analysed the mathematical and verbal test scores, and genome data, of a separate group of more than 260,000 people.

When exploring if the gene variants linked to bacteria were associated with markers of intelligence, they found that people who are genetically predisposed to have more *Oxalobacter* species in their gut had lower test scores, while those predisposed to have more *Fusicatenibacter* scored higher.

The extent to which these test scores reflect intelligence is, however, unclear. "Verbal and mathematical tests are a pretty good proxy for intelligence, [but] it's such a complex and multifactorial trait that can't be bottled down to one or two measures," says Kaitlin Wade at the University of Bristol, UK.

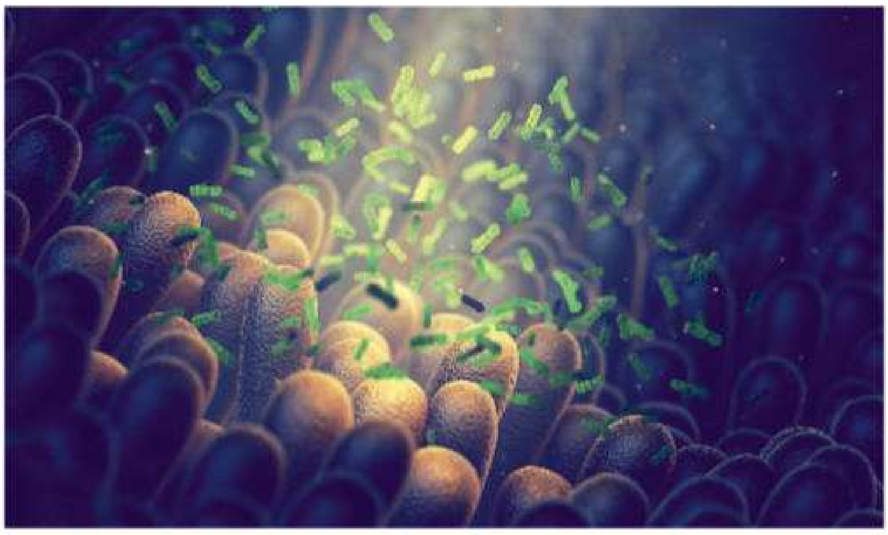
To gauge whether bacterial levels influence intelligence scores, rather than simply being correlated with them, the researchers also identified more than 150 genetic variants that have been associated with mathematical and verbal skills. They then looked for links between these variants and levels of the two bacteria, which suggested that the bacteria may directly affect intelligence.

In the case of *Fusicatenibacter*, the researchers also linked higher levels of the bacteria to a larger brain volume, which has been associated with intelligence. But how test scores might be reduced by the presence of *Oxalobacter* is unclear (medRxiv, doi.org/kd5j).

"It is too early to tell if you could take certain bacteria as a supplement to influence intelligence"

Whether people could one day increase their mental skills by changing their gut bacterial levels is uncertain. "It is too early to tell whether you could eventually take certain bacteria as a supplement to influence intelligence," says Wade.

What's more, the genetic variants involved in the study were less strongly linked to bacterial levels than one would like with this kind of analysis, says Wade. "Because we're massively limited in data on links between genetics and the microbiome, many microbiome studies using this type of analysis are using a much more lenient cutoff for defining that set of genetic variants." The study was also mainly made up of people of European ancestry, so further research is needed to see if the findings apply to other populations, she says. ▮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**There are many bacteria in the gut, and some may influence our verbal and mathematical reasoning**

**Medicine**

# Treatment hope for prion diseases

## A genetic therapy has brought the lifespans of infected mice almost back to normal

**Michael Le Page**

AN EXPERIMENTAL therapy has dramatically extended the lives of mice infected with prions, which cause conditions like Creutzfeldt–Jakob disease (CJD). The news, announced by biotech firm Sangamo Therapeutics, boosts hopes of developing treatments for these conditions.

"Mice die very rapidly if they are not treated. The average lifespan of the mice that are treated is starting to extend over 500 days, which is kind of the normal lifespan," says Jason Fontenot at Sangamo Therapeutics. "It's very effective."

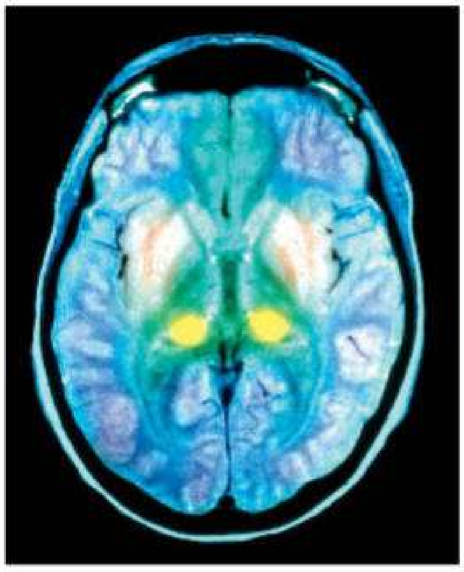
Prion diseases are unusual in that they are caused by a misfolded protein that makes other proteins of the same kind misfold too and join up to form damaging strand-like fibrils in cells. Fragments of fibrils spread the problem to other cells.

This causes serious damage to the brain, with death usually occurring within a year of the first symptoms of CJD being detected, for example. "It's a devastating disease," says Fontenot.

Some forms of CJD are caused by eating contaminated food – such as meat from cattle with another prion disease, BSE (bovine spongiform encephalopathy), also known as mad cow disease – or by surgical instruments or blood contaminated by prions.

Other instances are due to mutations that make misfolding more likely. However, with most cases of CJD, there is no clear cause – they may be a result of spontaneous misfolding.

**MRI brain scan showing two yellow areas with hallmarks of Creutzfeldt-Jakob disease**



SIMON FRASER/ROYAL VICTORIA INFIRMARY, NEWCASTLE UPON TYNE/SPL

In almost every prion disease, the protein that misfolds is one called PrP. Its normal function isn't clear, but mice and cows engineered so they can't make PrP don't seem to have any serious ill effects and they are immune to prion diseases because there is no PrP in their bodies to misfold.

So, efforts to develop treatments for CJD are taking aim at PrP. For their work focusing on this target, researchers at Sangamo Therapeutics created a protein that binds to a specific sequence of DNA near the gene that produces PrP and switches it off, preventing the protein from being made.

A gene to make this turn-off-PrP protein can be delivered into brain cells using viruses selected for their ability to target neurons.

To test the treatment, the researchers infected mice with prions. Untreated mice developed symptoms about 120 days later and all had died after around 160 days.

But mice lived much longer if they were given a single dose of the virus carrying the gene for the turn-off-PrP protein, with this treatment coming either 60 or 120 days after infection.

Ten of these 19 mice were still alive 360 days post-infection and five survived for 500 days, Sangamo Therapeutics revealed at a meeting of the American Society of Gene & Cell Therapy in Los Angeles in May.

"The work is encouraging," says John Collinge at the Institute of Prion Diseases at University College London, whose team has developed another potential treatment based on antibodies that target PrP.

Sangamo Therapeutics is now tweaking the turn-off-PrP protein to target the human gene for PrP, and the company hopes to begin human trials soon, says Fontenot.

In people, the viruses carrying the gene for the turn-off-PrP protein may need to be injected into spinal fluid or directly into the brain. ■

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**Biodiversity**

# Alligators create hotspots for life by digging with snouts

**THE alligators living in Florida marshes create nutrient-rich hotspots that help some other animals thrive.**

**American alligators (*Alligator mississippiensis*) use their snouts and tails to dig holes in which they can lounge, mate, eat and stay cool. These alligator ponds dot the marsh, a landscape otherwise dominated by a grass-like plant called spikerush (*Eleocharis cellulosa*), with watery basins.**

**"We know alligators are important predators, but we really don't have any idea if these ponds are important at the landscape level," says Bradley Strickland at the Virginia Institute of Marine Science.**

**So, he and his colleagues looked at 10 of these basins in South Florida's coastal Everglades. They assessed the types and number of plants, animals, algae and nutrients in three zones: inside the pond, near the pond's edge and in the marsh.**

**Overall, alligator ponds had greater diversity and abundance of life-giving nutrients like phosphorus than other areas, and hosted more creatures, from microscopic zooplankton to fish like largemouth bass (*Micropterus salmoides*).**

**Small crustaceans like copepods were between 30 and 100 per cent more abundant in ponds than nearby. Zones around ponds also had more invertebrates like copepods and aquatic mites than the marsh.**

**The ponds often hold water when the rest of the marsh desiccates in the dry season, so they can provide a refuge for aquatic species.**

**"We know now that alligators are more than just predators. They're ecosystem engineers"**

**Not everything was more abundant in alligator ponds. They hosted fewer plants than nearby areas, probably because deep water and disturbance from alligators prevents their growth. The marsh was home to more grass shrimp (*Palaemonetes*) and creeping water bugs (*Pelocoris femoratus*), which were largely absent from ponds (*Journal of Animal Ecology*, doi.org/gr9x2s).**

**"We know now through this study that alligators are more than just fierce predators," says Strickland. "They're ecosystem engineers." ■**

**Corryn Wetzel**

**Human behaviour**

## Collisions are less likely when you're walking as a couple

**Karmela Padavic-Callaghan**

**COUPLES are less likely to physically bump into other people when walking in busy public spaces than pairs of acquaintances or work colleagues are. However, adding a child into the mix makes the group more likely to have a collision.**

**To investigate how social bonds affect collisions, Takayuki Kanda at Kyoto University in Japan and his colleagues analysed more than 800 hours of video footage of pedestrians in two large, shared spaces in Osaka, Japan.**

**For each recording, they identified pairs of pedestrians and rated the strength of social interactions between them on a scale from 0 to 4, with the highest value designating romantic couples.**

**Comparing hundreds of couples and pairs of colleagues, family members and friends, Kanda and his colleagues determined that stronger social interactions between the pair meant fewer collisions with others. In other words, couples were less likely to get bumped into than pairs of co-workers or casual friends.**

**The researchers also observed that pairs of people coded as family members were more likely to get broken up by other pedestrians (arXiv, doi.org/kd4p).**

**Ioannis Karamouzas at Clemson University in South Carolina says many factors determine how people walk, including the design of the space and why they are there, but social dynamics clearly matter, too.**

**Imagine, he says, a couple walking together while holding hands: "We hardly ever try to break the group and go through it, but rather elect to go around it."**

**Using this information in computer simulations of pedestrians could help design more walking-friendly spaces in cities or inform how autonomous robots should navigate crowds, says Karamouzas.** ▮

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**Life**

# Tapeworm infection makes ants live three times longer

**Michael Le Page**

THATMACROGUY/SHUTTERSTOCK

***Temnothorax nylanderi* ants may benefit when a parasite gets into them**

ANTS infected with a tapeworm live several times longer than usual. How the parasite extends the life of its host is unclear, but a cocktail of proteins it releases may provide some clues.

The parasite is a tapeworm called *Anomotaenia brevis,* whose main hosts are several types of woodpecker. Ants of the species *Temnothorax nylanderi* sometimes collect woodpecker faeces and take them back to the nest to feed to larvae. If there are tapeworm eggs in the faeces, they hatch in the larvae guts, where the parasites burrow through the gut wall and develop in the body cavity.

Researchers at Johannes Gutenberg University Mainz in Germany have been collecting and studying infected ants from a nearby forest for decades. They have found that the tapeworm alters the behaviour of infected worker ants.

Such ants don't go out to forage, but instead remain in the nest, where uninfected workers care for them. "For the infected individuals themselves it seems positive," says Juliane Hartke, a member of the research team. "They don't need to do anything; they're still being fed. But what we do see is that the whole colony suffers."

Most strikingly, while normal workers die after around a year, the infected ants live for much longer. "We've looked at them for at least three years," she says. "Anecdotally, we've heard of seven years and maybe longer."

**260**

**Number of proteins a tapeworm releases into its ant host's body**

This benefits the parasite because even if it is several years before a woodpecker discovers an infected ant nest, some ants will still carry the parasite and infect the woodpecker if it eats them, completing the life cycle.

In their latest study, Hartke and her colleagues analysed haemolymph – the insect equivalent of blood – from ants infected with the parasite and uninfected ants. They found that the parasite releases 260 different proteins into the ants' bodies. "It's massive – we did not expect that," she says.

Two of the most abundant parasite proteins were the antioxidants superoxide dismutase and thioredoxin peroxidase. However, these substances may be released to protect the parasites from ant defences, says Hartke, rather than being the cause of the ants' longer lives. And in people at least, researchers have failed to find evidence that extra antioxidants delay ageing.

Most of the other secreted proteins couldn't be identified, having no known equivalents in other organisms (bioRxiv, doi.org/kd45).

"It's a cool strategy," says Carolyn Elya at Harvard University, who studies "zombie" fungi that manipulate the behaviour of insects. There are other examples of parasites lengthening lifespans, says Elya, though not by as much.

Another tapeworm (*Hymenolepis diminuta*) extends the life of a beetle that it infects (*Tenebrio molitor*) by around a third. *Plasmodium relictum*, the parasite that causes malaria in birds, also slightly increases the lifespan of its mosquito host (*Culex pipiens*).

It isn't unusual for parasites to secrete hundreds of proteins to manipulate their hosts, says Elya. Jewel wasps have been found to inject a cocktail of 264 proteins into their host.

Hartke now plans to try to find out what the unidentified proteins released by *A. brevis* do to the ant. This might reveal how to make ants live longer, she says, but is unlikely to have relevance to people. ▮

See page 18 for more life-extension findings

Computing

# AI finds new way to sort data

Millions of programs could run faster thanks to DeepMind discovery of better code

**Matthew Sparkes**

AN ALGORITHM used trillions of times a day could run up to 70 per cent faster, thanks to an artificial intelligence created by UK-based firm DeepMind. It has found an improved way for computers to sort data that has been overlooked by human programmers for decades.

"We initially thought there was a bug, then realised AlphaDev had discovered something faster"

"We honestly didn't expect to achieve anything better: it's a very short program, these types of programs have been studied for decades," says Daniel Mankowitz at DeepMind.

Sorting algorithms are a workhorse of computation, used to organise data by alphabetising words or ranking numbers from smallest to largest. Many types exist, but innovations are limited because they have been optimised over the decades.

Now, DeepMind has created an AI model called AlphaDev that is designed to discover new algorithms to complete a given task, with the hope of beating our existing efforts. Rather than tweaking current algorithms, AlphaDev starts from scratch.

It uses assembly code, which is the intermediate computer language between human-written code and sequences of binary instructions encoded in 0s and 1s. Assembly code can be painstakingly read and understood by humans, but most software is written in a higher-level language that is more intuitive before being translated, or "compiled", into assembly code. DeepMind says that assembly code affords AlphaDev more leeway to create algorithms.

The AI is told to build an algorithm one instruction at a time and tests its output against a known correct solution to ensure it is creating an effective method. It is also told to create the shortest possible algorithm.

When asked to create a sorting algorithm, AlphaDev came up with one that was 70 per cent faster than the best for lists of five pieces of data and 1.7 per cent faster for lists of over 250,000 items (*Nature*, doi.org/gsbv4z).

BEST-BACKGROUNDS/SHUTTERSTOCK

**Computers use sorting algorithms to alphabetise words or to rank numbers**

"We initially thought it made a mistake or there was a bug or something, but, as we analysed the program, we realised that AlphaDev had actually discovered something faster," says Mankowitz.

Because sorting algorithms are used so widely, the improvement could have a significant effect globally. Such algorithms are so vital that they are written into libraries of code that anyone can use, rather than writing their own. DeepMind has made its new algorithms open-source and included them in the commonly used Libc++ library, meaning people can already use them. This is the first change to this part of the sorting algorithm library in over a decade, says DeepMind.

Mankowitz says that Moore's law – the idea that the amount of computing power of a single chip doubles at regular intervals – is coming to an end because miniaturisation of chips is hitting physical limits. AlphaDev might compensate by boosting efficiency in algorithms that are run trillions of times a day in millions of programs, says Mankowitz.

Mark Lee at the University of Birmingham, UK, says even a 1.7 per cent speed boost is useful. But he is sceptical this approach will make up for Moore's law breaking, because it won't be able to make the same gains in more esoteric software. "I think increases in hardware are still going to outstrip it," he says. ▮

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Animal behaviour

# Harvestmen adapt wooing technique after losing a leg

THE loss of a leg makes a male harvestman more likely to adopt a stealthy approach to finding a mate later in life.

ERIN POWELL

Harvestmen can remove one of their own legs to escape a predator

Males of many types of harvestmen – sometimes known as daddy longlegs – have leg spurs and beefed-up head appendages that they use to battle for mates. In *Forsteropsalis pureora*, adult males come in three forms. Some of these arachnids have pincers in front of their mouth called chelicerae that are enlarged, being either stout and plier-like in dominant alpha males or elongated in beta males. Gamma males have small chelicerae and are sometimes seven times smaller. Alpha and beta males brawl, while gamma males avoid other males, searching for undefended females.

Erin Powell at the Florida Department of Agriculture and Consumer Services and her colleagues collected 86 adult male harvestmen on New Zealand's North Island, looking at their limbs and which category – alpha, beta or gamma male – they fit into.

Like many harvestmen, *F. pureora* can break off their legs to escape an attacking predator, but they can't regenerate lost limbs. The team could tell if legs were lost as juveniles or in adulthood based on the size of their scars. Males that lost legs as juveniles were 45 times more likely than those with intact limbs to become a gamma male (*Behavioral Ecology*, doi.org/kdtf).

Powell says it is possible that harvestmen that were already destined to become gamma males were just more likely to lose their legs, possibly because they were too slow to escape from predators.

Researchers have long wondered if genetics or environmental factors drive such distinct male morphs, says Bruno Alves Buzatto at Flinders University in Australia. In this case, the study shows "that it's quite environmentally determined". ▮

**Jake Buehler**

Mind

# Why you can stay focused on conversations in a noisy room

Jason Arunn Murugesu

WE NOW have a good explanation for how our brain keeps track of a conversation while we are in a loud, crowded room, a discovery that could improve hearing aids.

The general idea for speech perception is that only the voice of the person you are paying attention to gets processed by the brain, says Vinay Raghavan at Columbia University in New York.

"My issue with that idea is that when someone shouts in a crowded place, we don't ignore it because we're focused on the person we're talking to, we still pick it up," says Raghavan.

To better understand how we process multiple voices, Raghavan and his colleagues implanted electrodes into the brains of seven people to monitor the organ's activity while they underwent surgery for epilepsy. The participants, who were awake throughout the surgery, listened to a 30-minute audio clip of two voices.

During the half-hour period, the participants were repeatedly asked to change their focus between the two voices, one of which belonged to a man and the other to a woman.

The voices spoke over each other and were largely the same volume. At various points in the clip, however, one was louder than the other, mimicking the changing volumes of background conversations in a crowded space.

Raghavan and his colleagues then used the resulting brain activity data to produce a model that predicted how the brain processes the quieter and louder voices and how that might differ depending on which voice the participant was asked to focus on.

The researchers found that the louder of the two voices led to activity in both the primary auditory cortex, which is thought to be responsible for the conscious perception of sound, and the secondary auditory cortex, responsible for more complex sound processing, even if the participant was told not to focus on the louder voice.

"It opens the door to understanding how you process things you're not paying attention to"

"This is the first study to show using neuroscience that your brain does encode speech that you're not paying attention to," says Raghavan. "It opens the door to understanding how your brain processes things you're not paying attention to."

The researchers found that the quieter voice was only processed by the brain, also in the primary and secondary cortices, if they asked the participants to focus on that voice.

It then took the brain about 95 milliseconds longer to process this quieter voice as speech compared with when the participants were asked to focus on the louder voice (*PLoS Biology*, doi.org/kdtg).

"The findings suggest that the brain likely uses different mechanisms for encoding and representing these two different volumes of voices when there is a background conversation ongoing," says Raghavan.

This means that by targeting the mechanism used to perceive quieter voices, hearing aids could be made more effective, says Raghavan.

"If we could make a hearing aid that can tell who you're paying attention to, then we could turn up the volume on just that person's voice," he says.

The researchers plan to repeat the experiment using less invasive methods to record audio processing in the brain. "Ideally, we don't want to implant something in your brain to get sufficient brain recordings to decode your attention," says Raghavan. ▮

DIRECTPHOTO COLLECTION/ALAMY

**Despite hubbub in a bar, we can focus on what we want to hear**

Space

# Fast-growing galaxy offers window on the early universe

Jonathan O'Callaghan

ASTRONOMERS using the James Webb Space Telescope (JWST) have discovered a galaxy in the early universe that appears surprisingly mature, having grown a big inner core more quickly than expected.

The galaxy was found by a JWST survey called JADES, and we see it as it was 700 million years after the big bang, when it was perhaps just 100 million years old. Its mass is about 150th of the Milky Way's.

It had been thought galaxy formation was fairly tumultuous in the more-crowded early universe, with protogalaxies crashing together and merging or galaxies rapidly collapsing. But this galaxy seems to be growing in a more sedate manner typical of the later universe, with a central core and a surrounding star-forming disc.

Probing how galaxies grew in an early era known as the Epoch of Reionisation, which lasted from 400 million to a billion years after the big bang, wasn't possible until the advent of JWST, which has revealed details from this period.

The new galaxy, named JADES-GS+53.18343-27.79097, is barely 1500 light years across, about a 70th of the size of the Milky Way. "It's pretty compact," says William Baker at the University of Cambridge, who led the study. But its central core is comparable in mass to the cores of modern galaxies, while its outer disc is growing in size at a rate of about eight stars per year. The galaxy is expected to reach full size in about 3 billion years (arXiv, doi.org/kd6m).

"I think this shows that there are pockets of the [early] universe where things are calmer," says Christopher Conselice at the University of Manchester, UK. "It's also showing us that galaxy formation is happening much quicker than we thought." ▮

See page 36 for more JWST finds

Sexual behaviour

# Masturbation's evolutionary role

Solo sexual activity in male primates seems to cut the chance of catching infections

**Soumya Sagar**

PRIMATES of both sexes have been masturbating for millions of years and the practice seems to have evolved to boost reproductive success and reduce the chances of contracting a sexually transmitted infection (STI), in males at least.

Masturbation is nearly ubiquitous in primates, which include apes like chimpanzees as well as smaller monkeys and lemurs. "Masturbation seems like an evolutionary conundrum," says Matilda Brindle at University College London. "Why would evolution produce this seemingly non-functional and costly sexual behaviour that's very much a solo activity?"

Brindle and her team focused on two ideas. The postcopulatory selection hypothesis says male masturbation improves ejaculate quality and makes superior sperm available for fertilisation, boosting the chance of reproductive success. The pathogen avoidance hypothesis suggests that masturbation is a post-sex cleansing activity for both sexes.

To investigate, the researchers used nearly 400 data sources, including scientific papers and questionnaires they sent to zookeepers and primatologists.

NATURE PICTURE LIBRARY/ALAMY

**Bonobos indulge in a wide variety of sexual behaviour, including genital rubbing**

They coupled this with the primate evolutionary tree and estimates of the frequency of sexually transmitted pathogens.

Statistical analysis revealed that the males and females of the most recent common ancestor of all the New World monkeys, Old World monkeys and apes were likely to be masturbators.

"It's important to realise that masturbation is ubiquitous throughout the primate order, in both females and males, and is practised by captive and wild-living individuals. We hope that highlighting this helps to negate damaging attitudes towards masturbation, by demonstrating that it is part of a repertoire of healthy sexual behaviours," says Brindle.

The evidence backed both hypotheses for why masturbation evolved in male primates, finding that it gives them a better chance at reproduction and helps them prevent STIs (*Proceedings of the Royal Society B: Biological Sciences*, doi.org/kds9).

On the disease front, this could be because seminal fluid has antibacterial molecules and the force of ejaculation expels pathogens, say the researchers.

Smaller primates clean their genitals by licking and urinating after mating. But larger primates like bonobos lack the flexibility to lick their genitals, say the researchers, so might have adopted masturbation instead.

The data was inconclusive for females, however, says Brindle, and it is possible that female masturbation doesn't fit either hypothesis tested here.

Cyril Grueter at the University of Western Australia suggests other possible evolutionary reasons for the practice: "relaxation and reduced aggression, which may contribute to the maintenance of cohesion in these primate groups". ▮

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Physics

## A way to build sound-based quantum computers

**A CRUCIAL building block for quantum computers based on sound has been shown to work for the first time.**

**One way of building quantum computers is to encode information into quantum states of particles of light, then use mirrors and lenses to manipulate the information. Andrew Cleland at the University of Chicago and his colleagues set out to do the same with sound.**

**Sound is created when an object or a substance, like air, vibrates. We hear it as a continuous noise, but it is actually a collection of tiny chunks of vibration, or particles of sound, called phonons.**

**"Making a phonon requires that quadrillions of atoms move collectively, but in our experiment, each is a single quantum object," says Cleland.**

**His team built a chip-sized device that can create phonons one at a time and send them to other parts of the device. The chip is kept at close to absolute zero, so that the phonons exhibit quantum effects.**

**The researchers used a component called a beam splitter, which usually reflects and transmits received sound in equal parts. Instead of splitting a phonon, it made it assume a quantum superposition state where the particle was simultaneously being reflected and transmitted.**

**Cleland says this mimics a necessary step for running calculations on light-based quantum computers. The researchers also recreated, with phonons, the way two particles of light are made to "talk to each other" and how their behaviour is controlled in computations. To do this, they sent two phonons from opposite directions into the beam splitter and saw their respective superposition states influence each other (*Science*, doi.org/kds8).**

"Phonons are somehow more 'meaty' than light, but they are showing the same quantum behaviour"

**"Phonons are somehow more tangible, more 'meaty' than light, but they have been showing the same quantum behaviours. This is amazing to me," says Cleland."** ▮

**Karmela Padavic-Callaghan**

Coronavirus

## Metformin may cut the risk of long covid by 41 per cent

Sara Novak

**THE diabetes drug metformin could prevent long covid, although it is unclear if it can also help treat people who already have the condition.**

**An estimated 65 million people worldwide have some degree of long covid, which can involve chronic fatigue, brain fog, heart and lung problems, and loss of taste and smell, among other issues.**

**With preventative drugs and other treatment options being limited, Carolyn Bramante at the University of Minnesota and her colleagues tested the potential of several therapies, including metformin, which is commonly used to control blood sugar levels in people with type 2 diabetes and has been shown to limit the replication of the coronavirus in the lab.**

**The team looked at 1126 people, aged 30 to 85, who had tested positive for SARS-CoV-2 within the past three days. They were all overweight or obese, which can raise the risk of severe covid-19, but they didn't require hospital care for the infection.**

**The participants were randomised to receive a range of potential treatments, including combinations of metformin, the anti-parasitic drug ivermectin, the antidepressant fluvoxamine or a placebo.**

**At a 10-month follow-up, 6.3 per cent of those who took metformin had been diagnosed with long covid, compared with 10.4 per cent on placebo, suggesting that the drug prevented 41 per cent of long covid cases in the trial. Neither ivermectin nor fluvoxamine reduced the risk (*The Lancet Infectious Diseases*, doi.org/gsb499).**

**While metformin may prevent long covid among people who are overweight or obese and who have a mild SARS-CoV-2 infection, the drug's potential in other groups, or as a long covid treatment, remains unclear.** ▮

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Geology

# Dried-up lake may explain lack of Californian quake

James Dinneen

CALIFORNIA is overdue for a major earthquake on the southern San Andreas fault, which could be down to the absence of a large lake that may have triggered past quakes.

The San Andreas fault runs through California for 1200 kilometres, forming the boundary between the Pacific and North American tectonic plates. The southern section of the fault, east of Los Angeles, has been abnormally quiet, with no large earthquakes for nearly 300 years despite an average gap between quakes of 180 years over the past millennium. Movement of the plates has also built up a large amount of stress within the fault.

"It is 10 months pregnant," says Ryley Hill at San Diego State University in California. He says a large earthquake on the fault poses the biggest seismic hazard in the state and could cause thousands of deaths and hundreds of billions of dollars in damage.

**An aerial view of the dried-up Lake Cahuilla in California**

DAVID MCNEW/GETTY IMAGES

A possible explanation for this delayed quake is the disappearance of Lake Cahuilla over the fault. For millennia, this lake formed when the Colorado river altered course and dried up when it shifted back. But the lake last dried out near the end of the 18th century and the floods that might have refilled it are now prevented by dams on the river.

300

**Number of years since the last major earthquake on the southern San Andreas fault**

Before the lake vanished, its added weight, as well as water seeping from it, could have increased the pressure of fluid within the fault. Hill says this may have reduced friction between the fault surfaces, like the air between an air hockey table and a puck. However, until now it was unclear whether this would have been enough to trigger a major earthquake on the southern San Andreas.

To find out more, Hill and his colleagues studied layers of sediment from a location near the edge of the dried-up lake, attempting to identify periods when the lake was full.

They discovered that six of the seven major earthquakes in the area over the past 1100 years occurred close to the time when the lake was filled. The seventh quake, which happened around 1000 years ago, might have also taken place when the lake was filled, but its precise date was too ambiguous to be sure, says Hill.

The researchers also modelled how the added weight of water in the lake would affect pressure within the fault, finding that rapid filling on its own could add enough pressure to trigger an earthquake (*Nature*, doi.org/kds7). Conversely, the absence of the lake over the past few centuries has had a "stabilising" effect on the fault, says Hill. "That air hockey table is getting turned off."

While that may have deferred the inevitable earthquake on the fault, the delay could have enabled more stress to accumulate, says Hill. That could make the eventual earthquake bigger when it comes, he says.

More accumulated stress won't necessarily lead to a bigger earthquake, says Danny Brothers at the US Geological Survey. There could be two smaller earthquakes, rather than a single large one, for instance, he says.

Even so, Brothers says the link between the filled lake and quakes is convincing, although more work is needed to nail down the precise dates.

"If the lake never comes back, we might be entering a new tectonic regime on the fault," he says. ▮

Reproduction

# Cats could get lifetime contraception

Single injection may prevent cats getting pregnant and it should work in other species too

**Michael Le Page**

A NON-SURGICAL, single-dose contraceptive has remained effective for at least three years in six female cats, and the effect is expected to last for the rest of their lives. If it does, the injection could replace surgery as a means of preventing pregnancies in cats.

It would also be the first permanent, non-surgical contraceptive in any animal. "If this is truly lifetime contraception, then it would be the first lifelong contraception that I'm aware of," says William Swanson at the Cincinnati Zoo & Botanical Garden in Ohio, who helped develop it.

It should be possible to adapt the technique for other mammals, too, perhaps including people. A one-dose permanent contraceptive would help control populations of many animals – especially feral or invasive ones – without having to kill them.

There are already a number of products that provide long-lasting contraception in some species.

For instance, some wild horses in the US are darted with a vaccine called PZP, which provokes an immune reaction in females that prevents pregnancies. However, repeated doses are required.

In cats, spaying is the only permanent way to prevent females having kittens. This is a costly procedure that involves removing the ovaries, or ovaries and uterus, under anaesthetic.

Now, Swanson and his team have developed an approach that involves an injection into the thigh muscle. It contains DNA that codes for a protein called anti-Müllerian hormone. The DNA is carried by a virus that delivers it to the nucleus of muscle cells, where it remains indefinitely.

**Birth control is one way to keep feral cat numbers down**

TUUL AND BRUNO MORANDI/PHOTODISC/GETTY IMAGES

Mammals naturally produce anti-Müllerian hormone, but the injection raises the levels to between 100 and 1000 times higher than normal, which stops the development of egg follicles in the ovaries, says Swanson.

In a trial, six female cats received the contraceptive and three received a dummy injection. Each cat was housed with a male with proven fertility for two four-month periods. All untreated cats got pregnant, but none of those given the contraceptive did (*Nature Communications*, doi.org/kdqk). "The cats are completely healthy. We are not seeing any adverse effects," says Swanson.

Muscle cells persist for a lifetime, and those with the added gene should keep producing the hormone, says Swanson. "That's why we target muscles."

Technically it isn't sterilisation, he says, as lowering levels of the hormone would restore fertility.

Other species have different versions of anti-Müllerian hormone, so the injection would only work in them if it were altered to include their version of the gene. This means if anyone accidentally poked themselves with a needle while injecting cats, their fertility should be unaffected.

"Surgery, especially in feral animals, has extensive stress and cost involved," says Aime Johnson at Auburn University in Alabama. "A simple injection would allow trapping, injection and release immediately."

The injection would have fewer animal welfare implications than spaying, says Patricia Fleming at Murdoch University in Perth, Australia, but cats would still be left on the streets to encounter trauma, injuries, human persecution or potential starvation. "Their wildlife impacts would also continue," she says. ▮

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Space

# Recent supernova used to help search for signals from ET

**ASTRONOMERS are looking towards a recent supernova for alien radio signals, in the hope that an advanced civilisation might be trying to communicate with us.**

**Last month, a supernova dubbed SN 2023ixf was spotted in the Pinwheel galaxy 21 million light years away, the closest stellar explosion detected from Earth in a decade. Earlier this year, an idea was put forward suggesting that supernovae like this might be good opportunities to search for extraterrestrial intelligence.**

**Supernovae are so bright that they can outshine their galaxies. The idea is that an alien civilisation that sees them might therefore use them as beacons by sending signals towards stars to arrive at a time when any advanced life there might well be looking at the supernova.**

**James Davenport at the University of Washington and his colleagues are now putting this to the test. Using two radio telescopes on Earth, they are observing about 100 stars within about 300 light years of Earth that should have already seen the light from the supernova and might now be trying to communicate with us – if there are inhabited planets around them (arXiv, doi.org/kdtj).**

"Within a week of the event, we started taking data. There are no signals yet"

**"Within a week of the event, we started taking data," says Davenport. "There are no signals yet."**

**While the chances of detecting anything are slim, Davenport argues it is worth a look. "The worst thing to happen would be for a signal to come in and us not to notice because we didn't bother to look," he says.**

**The search also raises the question of whether we should send our own directed signals the next time we see a nearby supernova, says Davenport. ▮**

**Jonathan O'Callaghan**

Physics

## Extremely cold drop of helium can be levitated forever

Karmela Padavic-Callaghan

**A DROP of liquid helium can be made to float in a cold vacuum, potentially indefinitely. In this state, it could serve as a mini-laboratory for fundamental physics.**

**Charles Brown at Yale University and his colleagues placed a helium droplet in a vacuum inside a powerful refrigerator to take the temperature down to -269°C. Quantum effects make liquid helium's viscosity vanish when it is this cold and turn it into a superfluid. This makes it repel magnetic fields, allowing the researchers to levitate it with powerful magnets made from coils of superconducting wires. "These are really at the limit of superconducting magnet technology," says Jack Harris, also at Yale University, who led the project.**

**The droplet was able to defy gravity for an unprecedented 20 hours, until the researchers turned off the magnets. Over time, the droplet slowly shrank, owing to evaporation caused by the tiny amount of heat entering the chamber. Mathematically modelling the experiment, the researchers showed that as the drop continued to shrink, it would become colder, which would cause its evaporation to slow down. Eventually, it would settle on a size at which it could levitate forever, says Brown (*Physical Review Letters*, doi.org/kdqn).**

**J. Peter Toennies at the Max Planck Institute for Dynamics and Self-Organization in Germany says the relatively large size of the superfluid droplets means they could be used as cold containers in which to study other molecules.**

**Exposing a droplet to an electric field could also help clarify whether the charges of electrons, neutrons and protons in matter actually add up to zero, says Harris. If an electric field moved a droplet, it would be reasonable to conclude that there is some unexpected charge imbalance within it, he says.**

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Evolution

# Earliest complex life may have lived 1.6 billion years ago

Alice Klein

STEROID molecules found in 1.6-billion-year-old rocks in Australia are believed to be remnants of a "lost world" of organisms that comprised the earliest complex life.

"We say they are a lost world, firstly because they are extinct, and secondly because we know virtually nothing about them," says Jochen Brocks at the Australian National University in Canberra, who led the study.

The earliest life forms on Earth were simple, single-celled organisms like bacteria that emerged more than 3 billion years ago. At some point came more complex organisms called eukaryotes, whose cells have a nucleus. These eventually evolved into all today's animals, plants, fungi and algae.

The oldest confirmed eukaryote fossils are red and green algae found in 1-billion-year-old rocks in Canada and China. Eukaryote fossils are confirmed by their shape and the detection of steroids – molecules that eukaryotes use to build cell membranes – co-located in the same rocks.

Older fossils that look like they might be eukaryotes have been found in rocks dating back 1.6 billion years, but scientists haven't been able to find the telltale steroid molecules that should be associated with them.

Now, evidence collected by Brocks and his colleagues suggests these older fossils are in fact eukaryotes, but a more primitive form that produced simpler steroid molecules known as protosteroids.

When modern eukaryotes make steroids, including cholesterol, they follow a 12-step biochemical pathway. The molecules made in the first few steps are protosteroids.

BLICKWINKEL/FOX/ALAMY

**Ciliates, which exist today, may share characteristics with early complex life**

Brocks and his colleagues found examples of these protosteroids in 1.6-billion-year-old rocks collected from the McArthur river mine in Australia's Northern Territory, an area that once formed an ancient seabed. They did this by grinding up the rocks and chemically analysing them.

The researchers then studied other rocks from around the world and also found abundant protosteroids in those that were between 1 billion and 1.6 billion years old. This suggests that the earliest eukaryotes emerged at least 1.6 billion years ago and made protosteroids (*Nature*, doi.org/kdqm). About 1 billion years ago, eukaryotes evolved the ability to make modern steroids, which presumably conferred advantages that allowed them to thrive as earlier eukaryotes died out, says Brocks.

These more sophisticated eukaryotes later evolved into algae, fungi, plants and animals that all produce modern steroids. The first animal eukaryotes, for example, emerged about 600 million years ago.

The research supports the late biochemist Konrad Bloch's hypothesis that, long ago, "maybe there were organisms that only produced the first step and then the second step and then the third step of the cholesterol biosynthetic pathway", says Brocks. "They're the molecules we found – those ones in the early steps."

"I think this may turn out to be another important piece in the puzzle of early eukaryotic evolution," says Birger Rasmussen at the University of Western Australia.

We don't know what the earliest protosteroid-producing eukaryotes would have looked like, but Brocks believes they were marine organisms that were much bigger and more complex than bacteria. "Bacteria are just simple blobs, but eukaryotes have protein skeletons called cytoskeletons that mean they can have all sorts of protrusions and ornamentations," he says. Living eukaryotes with features like this include organisms called ciliates (pictured).

If the 1.6-billion-year-old eukaryote-like fossils are found to be co-located with protosteroids, this would confirm that they were these primitive eukaryotes and give some clues about their appearance, says Brocks.

One remaining question is if anything else other than eukaryotes could have produced the protosteroids found in the ancient rocks. Some bacteria are known to make protosteroids, although they are unusual. "That is the biggest uncertainty in the study and will definitely be the focus of our future research, to see if bacteria played any role," says Brocks.

Ageing

# Taurine supplements may extend lifespan and health as we get older

**Chen Ly**

SUPPLEMENTS of the amino acid taurine may keep us healthy and potentially even extend our lives, according to experiments in mice and monkeys.

Found in many animals, including humans, taurine is naturally made in the pancreas and can also be obtained by eating animal products. Previous studies have found that taurine deficiencies in early life impair the skeletal muscle and central nervous system in mice, as well as causing retinal degeneration in mice and cats. But little is known about what role taurine might have in ageing.

To learn more, Vijay Yadav at Columbia University in New York and his colleagues measured taurine concentrations in the blood of mice, monkeys and humans, finding that its levels declined as they all aged.

Among the human participants, those aged around 65 had taurine levels that were more than 80 per cent lower than those of the study's infant participants.

> "Mice given taurine were leaner and had improved bone density and muscle strength"

In a separate analysis of nearly 12,000 60-year-olds, higher taurine levels correlated with various markers of better health, including a lower prevalence of type 2 diabetes and reduced inflammation.

Next, the researchers wanted to see if reversing taurine's decline could improve animals' health as they aged and potentially extend their lifespan, so they gave daily taurine supplements to 14-month-old mice, the equivalent of a person aged between 45 and 50.

On average, these mice lived up to 12 per cent longer than those that weren't given taurine. They also had reduced signs of ageing, such as less DNA damage and mitochondrial dysfunction. "They were leaner, had improved bone density and muscle strength and had a younger-looking immune system, among other benefits," says Yadav.

In the monkeys, the researchers didn't assess the effect of the supplements on their lifespan, but did link them to a healthier liver, body mass, immune system and bone density (*Science*, doi.org/gsbvwq). "In other words, supplements made monkeys healthier for longer," says Yadav.

The researchers hope to repeat their experiment in people, but in the meantime, they don't recommend that people take taurine supplements in the hope of living longer.

"We need to wait for a large-scale, randomised-controlled taurine intervention before taurine supplementation can be safely recommended for people," says Yadav.

"Although more clinical studies are still needed, this study provides relevant scientific support that taurine supplementation may have a positive impact on promoting healthy longevity in humans," says Cláudia Cavadas at the University of Coimbra in Portugal. "However, it is important to never forget that a healthy lifestyle is essential for achieving a healthy lifespan." ■

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Genetics

# Octopuses edit their own RNA to adapt to cold water

OCTOPUSES can adapt to changes in temperature by tweaking their genetic code to alter the proteins that are made in their nerve cells.

Previous work has shown that cephalopods, such as squid and octopuses, can edit their RNA. These "messenger" molecules carry a copy of genetic instructions from DNA to parts of the cell where proteins are made. But it was unclear why the animals do this or what it does.

To investigate, Joshua Rosenthal at the Marine Biological Laboratory in Woods Hole, Massachusetts, and his colleagues gradually shifted the water temperature in the tanks of California two-spot octopuses (*Octopus bimaculoides*, pictured).

Octopuses in a tank at 13°C (55°F) made more than 13,000 edits to their RNA that led to changes in the resulting proteins than those in a tank at 22°C (72°F).

"It's tempting to think they're doing this to acclimate to a changed environment," says Rosenthal.

Many animals, including humans, have enzymes that can swap letters in RNA to change those instructions. However, most edits take place in non-coding RNA – that is, RNA that isn't translated into a protein. These edits may be useful in other ways; for example, they can affect how cells in our immune system develop.

"What is interesting about cephalopods is that they recode proteins in a magnitude that is much higher than any other species or any other family of animals that we know," says Eli Eisenberg at Tel Aviv University in Israel, who also worked on the study.

NORBERT WU/MINDEN PICTURES/ALAMY

Recoding their proteins may help octopuses adjust to temperature changes

Two of the proteins that were altered significantly in response to temperature were kinesin-1 and synaptotagmin – both critical for the functioning of the nervous system.

Kinesin-1 transports chemical cargo through long microtubules inside neurons, which can extend to a metre in length. The RNA editing changed part of the kinesin's "foot", where it connects to the microtubules, so it travelled more slowly (*Cell*, doi.org/gsbtjc).

Synaptotagmin is found at connections, or synapses, between neurons, where it senses calcium levels and triggers the release of chemical messages from one cell to another. The RNA editing gave the synaptotagmin a lower affinity for calcium when it was colder.

Eisenberg says it is too early to know how these changes might help octopuses adapt to cold. However, the researchers think the timescale at which the shifts occur suggests the changes are suited to seasonal temperature differences, rather than sudden changes, such as those caused by water currents. ■

**Jacklin Kwan**

**Reproduction**

## Crocodiles can breed without any males

A FULLY formed crocodile fetus has been found in an egg laid by a female that had no contact with males, showing that "virgin birth" is possible in these animals.

The female fetus – which died at full-term – is a near genetic replica of its mother, a healthy adult kept in an isolated enclosure in a Costa Rican reptile park for 16 years (*Biology Letters*, doi.org/gsbq33).

Parthenogenesis, a form of asexual reproduction in which embryos develop from unfertilised eggs, occurs in some snakes, lizards and even turkeys. The discovery in a crocodile suggests it might date back to a shared ancestor of these reptiles and birds at least 267 million years ago, and that dinosaurs and pterosaurs may have been able to reproduce without males too. **Christa Lesté-Lasserre**

**Technology**

## Robot outcompetes human gardeners

AN AUTOMATED robot gardener has shown its nurturing side by matching humans in trials of growing vegetables.

Simeon Adebola at the University of California, Berkeley, and his colleagues have developed an automated plot, called AlphaGarden, that contains a mix of eight vegetable types and tested whether it can perform as well as a team of six horticulturalists.

The humans planted, watered and trimmed as they saw fit, and AlphaGarden used modelling, robotic pruning and watering controls to work out how best to grow the plants.

AlphaGarden produced a similar amount of vegetables, but used 40 per cent less water, Adebola told the IEEE International Conference on Robotics and Automation in London on 30 May (see Columnist, page 22). **Alex Wilkins**

ROBIN WEAVER/ALAMY

**Mind**

## How the brain may make us scared of heights

A BRAIN circuit that mediates a fear of heights has been identified in mice, a discovery that could help improve treatments in people who experience an extreme reaction to high places.

A fear of heights, often accompanied by anxiety and dizziness, is thought to be an in-built physiological response that evolved to help prevent injuries from falling. But 3 per cent to 6 per cent of people have acrophobia, an intense version of this that can affect their quality of life.

To better understand why this occurs, Wei Shang at East China Normal University in Shanghai and his colleagues placed mice on a high, open platform, noting that they approached the edge cautiously before moving back or turning away, behaviour that is similar to people with acrophobia.

Further analysis revealed that exposure to heights activated neurons in a midbrain structure called the periaqueductal grey. When the researchers disabled these cells, the animals fearlessly explored the platform edge, even hanging from it or falling off.

More experiments showed that silencing linked neurons in the lateral geniculate nucleus, part of the visual system, or activating neurons in the superior colliculus, also helped to suppress this fear of heights (bioRxiv, doi.org/kds6).

The researchers now plan to work with psychologists to investigate whether these mechanisms also apply to humans. "Our long-term goal is to reveal how physiological fear of heights evolves into acrophobia and develop treatments for this condition," says senior author Xiaobing Yuan. **Moheb Costandi**

## *Really* brief

DANIEL HEUCLIN/BIOSPHOTO/ALAMY

### Snakes move in a quantum way

An equation developed to describe the motion of animals like snakes and centipedes looks like the Schrödinger equation from quantum mechanics. This may be because the animals have finite length and lots of symmetry, like some abstract quantum states (*Physical Review Letters*, in press).

### Plane turbulence is getting worse

Had a bumpy plane ride recently? You can blame climate change. An analysis suggests turbulence has increased around the world over the past four decades, in line with predictions that warmer air will trigger alterations to air currents in the upper atmosphere (*Geophysical Research Letters*, doi.org/kds5).

### Dog sniffs out rare newt hiding places

Researchers have trained a dog to use its nose to detect threatened great crested newts (*Triturus cristatus*) with more than 87 per cent accuracy even when the amphibians are deep below the soil. The skill could help us learn more about the mysterious terrestrial part of the newt's life (*PLoS One*, doi.org/gsbrpm).

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# Views

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**Alex Wilkins** on what happens when AI meets robotics p22

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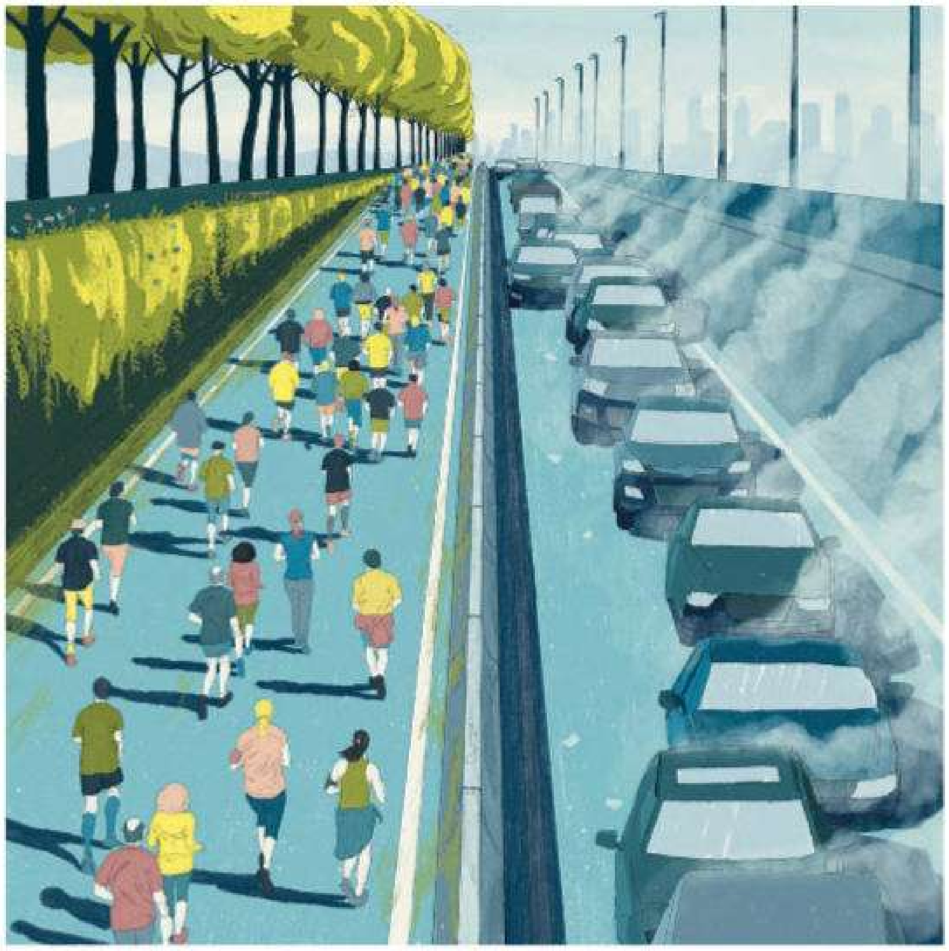
**Culture**
An intriguing look at what really sets the generations apart p28

**Culture columnist**
**Simon Ings** dives into a compelling story of conservation p30

**Comment**

# How to breathe easy

Tackling our toxic air is crucial, not just for good health, but as a means to confront the climate crisis, says **Sadiq Khan**



SIMONE ROTELLA

ALL human life is powered by breath. But not all of us breathe the same air.

According to the World Health Organization, air pollution is a public health emergency – 99 per cent of the global population breathe toxic air. The 9 million early deaths from air pollution-related diseases worldwide each year are on a par with the number caused by tobacco smoking.

And yet tainted air's effects aren't evenly spread. The harm caused by it is concentrated among the most disadvantaged people in society. More than 90 per cent of air pollution-related deaths occur in low and middle-income countries. In many higher-income countries, air pollution is a social justice issue too, with the poorest and those from ethnic minority backgrounds least likely to own a car, but worst affected by dirty air.

Before I was elected mayor of London in 2016, I barely thought about air pollution. As I explain in my new book *Breathe*, I spent the early part of my 30s driving around London in a gas-guzzling Land Rover Discovery. I even voted for a third runway at Heathrow Airport as an MP. It was only when I was diagnosed with adult-onset asthma in 2014 – brought on by breathing London's polluted air while training for the city's marathon – that I started to realise the scale of the problem. I was scandalised: I couldn't believe I had been made ill just by inhaling the air of the city I love.

Over the next few years, I would find myself reflecting more deeply on the links between climate change and health. After my diagnosis, I began to notice the cars idling outside schools and the exhaust fumes streaming out of vehicles in gridlocked traffic. I learned that in London alone, around 4000 people die prematurely each year because of toxic air. And, in turn, I started to learn something crucial about environmental politics.

The received wisdom among politicians is that climate policy is a vote loser; that people think of climate change as a "tomorrow" issue rather than a "today" issue. But air pollution proves how wrong that is. After all, the main causes of climate breakdown – greenhouse gases, particularly from transport, industry and power generation – are also the key causes of air pollution.

That means environmental policies needn't focus solely on climate change tomorrow. You can get people to focus on the polluted air they are breathing today. It is buy one get one free: tackle air pollution and tackle the climate emergency at the same time.

This insight is what led me to team up with Rosamund Kissi-Debrah, one of the most remarkable women I have met. Her daughter Ella tragically died at the age of 9, the victim of a form of asthma exacerbated by her home's proximity to London's South Circular Road. Rosamund and I first collaborated to help get air pollution recognised as a cause of death on Ella's death certificate, a first in the UK.

In the years since, Rosamund has continually emphasised the need to do more, and faster, on air pollution. She has been a key ally in the successful push to expand London's Ultra-Low Emission Zone later this year, which penalises the use of more-polluting vehicles. The initial zone contributed to the toxicity in central London's air falling by almost 50 per cent in two years and a 94 per cent reduction in the number of Londoners living in areas with illegal levels of nitrogen dioxide.

This should give us all hope that we can successfully tackle the climate emergency and dirty air. But we need to do more on air pollution, and faster. My book is a guide to how we do that.

People like Rosamund point the way to a better green politics. She taught me that we aren't just in a climate crisis, but a health one too. If we can convince people of the need for cleaner air, we can also take on the climate emergency. ▮

Sadiq Khan is mayor of London and author of *Breathe: Tackling the climate emergency*

### Artificially intelligent

## Rise of the machines

From self-driving cars to humanoid robots, robotics is an area of research that gets less attention than it deserves given its potential impact, says **Alex Wilkins**

Alex Wilkins is a *New Scientist* reporter covering artificial intelligence, physics and space. *Artificially intelligent* is a column that cuts through the hype and looks at what AI is really capable of and what it means for us. You can follow him @AlexWilkins22

### Alex's week

**What I'm reading**
Seeing Like a State *by James C. Scott, a look at how things go wrong when state schemes to improve society fail.*

**What I'm watching**
Beef, *a Netflix series about escalating acts of revenge between two angry drivers whose lives become intertwined.*

**What I'm working on**
*There's no time like the summer to finally get the garden into shape – no easy task for a hayfever sufferer like me.*

**New Scientist video**
**Watch Alex Wilkins try out robot avatars at the ICRA robotics conference**
**youtube.com/newscientist**

This column appears monthly. Up next week: Chanda Prescod-Weinstein

IF WE take the assertions of prominent tech CEOs at face value, humanity could be risking extinction if artificial intelligence is left to its own devices. Large language models like those that power ChatGPT have shown the first sparks of intelligence, they say, and might lead to armageddon (although the specifics of exactly how have yet to be fleshed out). A few weeks ago, I found myself in an alternate AI reality – with zero mention of human extinction or analogies to nuclear war – when I attended the world's largest robotics summit, the IEEE International Conference on Robotics and Automation (ICRA) in London.

It was a breath of fresh air to see how AI is being applied in an entirely different domain, though there are problems and societal risks with intelligent robots, too. How can robots adapt and learn in the real world without endangering people? Why is communication between fleets of robots such a hard and potentially dangerous problem? This area of AI research gets much less of the limelight than it deserves, given the outsize impact it could have on our future.

If you have seen robots on social media, like Boston Dynamics' acrobatic android Atlas doing flips off a platform or the eerie humanoid robot Ameca being interviewed on *This Morning*, you might think robots already seem quite capable – but there is an element of smoke and mirrors here. Such robots have been trained to perform a narrow range of tasks in structured environments. When I go to the supermarket and see they have run out of eggs, I can adjust and try to find them in another shop, but a robot can't yet do the same.

As Chelsea Finn at Stanford University in California told a packed crowd at ICRA, what we need is robots that can adapt to the almost infinite number of scenarios they might encounter. "Instead of programming robots or training them and deploying a fixed policy, maybe we can have robots adapt on the fly during deployment when they are in the real world," she said.

Adapting and learning how to learn is a vast area of robotics research and we are beginning to see the first fruits of success in real-world scenarios.

Earlier this year, I reported on a project from Google's robotics team that saw robots learn how to separate waste into recycling, compost and rubbish. This fleet of robots was taught using reinforcement learning, where a robot is shown a successful outcome and left to figure out how to achieve it by trial and error using a system of feedback. After lessons in robot classrooms and roaming the uniquely filled bins of Google's offices for two years, the robots could sort the trash with 84 per cent accuracy.

> **"What we need is robots that can adapt to the almost infinite number of scenarios they might encounter"**

A particularly interesting feature of this robotic fleet is that if one robot learns, they all learn. Although the robots are siloed in their physical bodies, they all share the same model of how to sort through a bin. This shared, or collective, intelligence is another thriving research field and something suited to robots. While humans rely on many forms of collective intelligence, we are limited by our communicative speed. Fleets of robots, however, can send lightning fast messages between one another.

"We're at a time where robotics is becoming more pervasive, distributed and connected," Amanda Prorok at the University of Cambridge told an audience at ICRA. Groups of robots that might communicate are everywhere: driverless cars, autonomous warehouse robots, swarms of drones. But for individual robots to use the data they are gathering and then communicate it with each other intelligently is hard. Errors and uncertainties in communications can quickly compound and spiral out of control, and the real, noisy world is full of these errors.

Prorok demonstrated how even a simple problem – like ensuring the flight paths for a few drones aren't disturbed by the gusts of wind from each other's rotors – requires complex, cutting-edge AI. Scaling up these sorts of problems to much larger systems will involve a lot of work, and the downsides of getting it wrong are potentially large. If you are driving somewhere and your car ends up sandwiched between two moving driverless ones, it might make sense for those two vehicles to communicate about what is happening, but those communications must be fair and avoid endangering you.

Despite these potential pitfalls, I couldn't help but feel excited at the future as it was presented at ICRA. There is a chance that much of this will fail – fully automated cars have been just around the corner for over a decade – or descend into a dystopia, as we have seen with drone warfare in Ukraine. But I was heartened by the brainpower and resources being poured into delivering on robotics' positive promise. ▮

# *A special anniversary is coming up soon!*

**AQUILA Magazine** will be 30 years-old in June, and over the years we have covered a multitude of topics: from puppets to ancient Pompeii, we have investigated quantum computers and interviewed volcanologists. Some of our readers are eight years old, and some are 80… but they all have something special in common: they are all curious, compassionate and creative, and they are FULL TO THE BRIM with BIG ideas! Some live in big cities and others live in the country with their dogs and chickens for company. Some may like gymnastics or wildlife – they might be scientists, write plays or music, or even paint masterpieces. Join us as we celebrate three decades of inspiring young minds with knowledge, imagination and endless possibilities.

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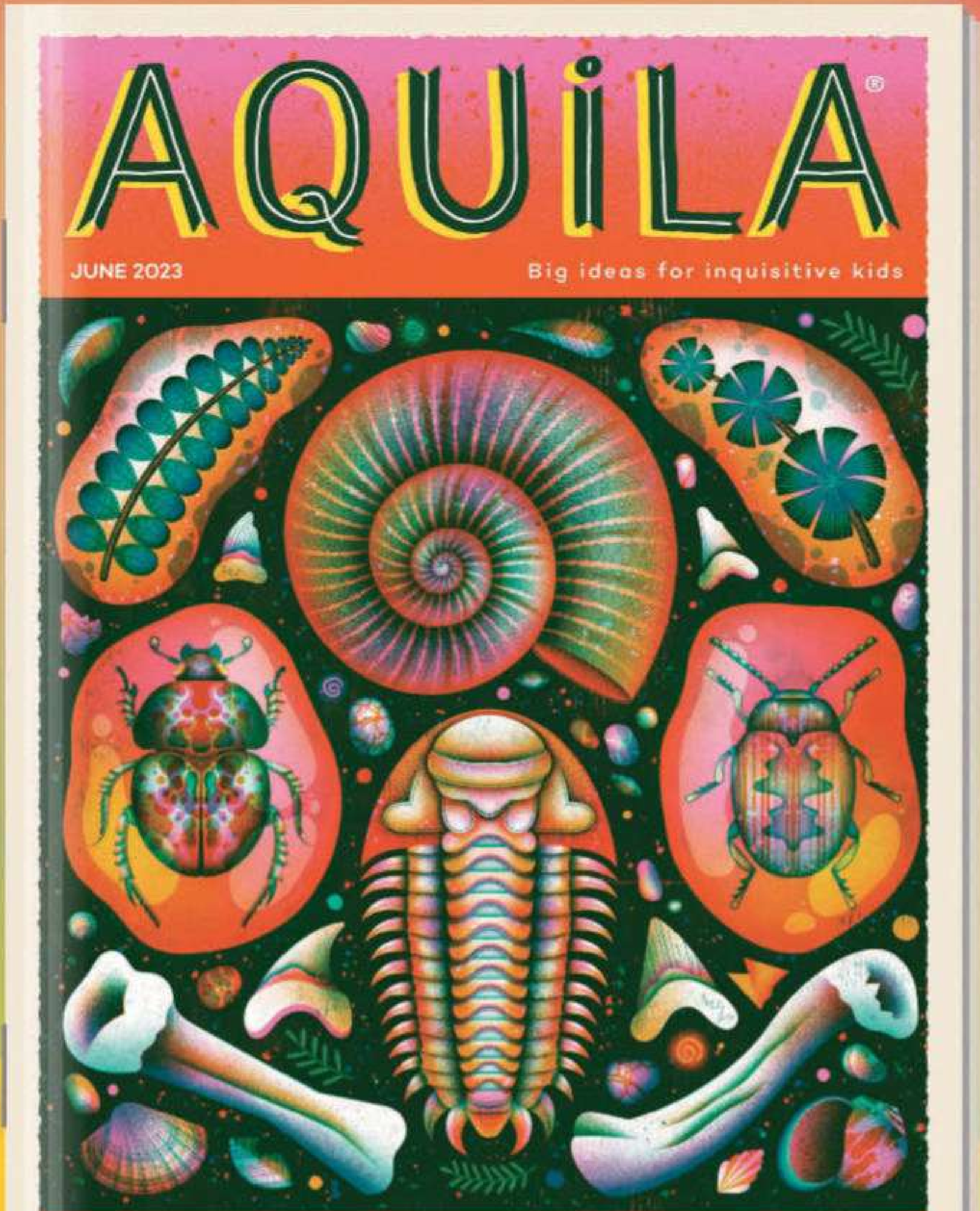

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All kids adore the fun of fossil hunting. Enjoy lots of science and history in this great topic which includes glorious art and craft projects to be enjoyed by the whole family.

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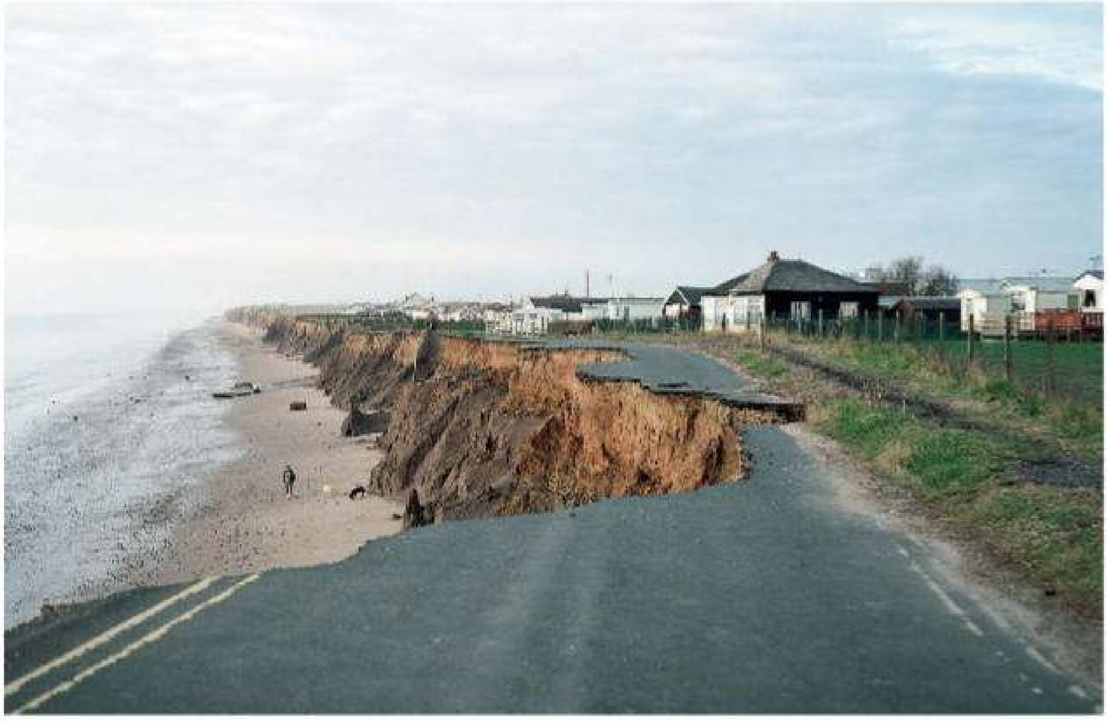

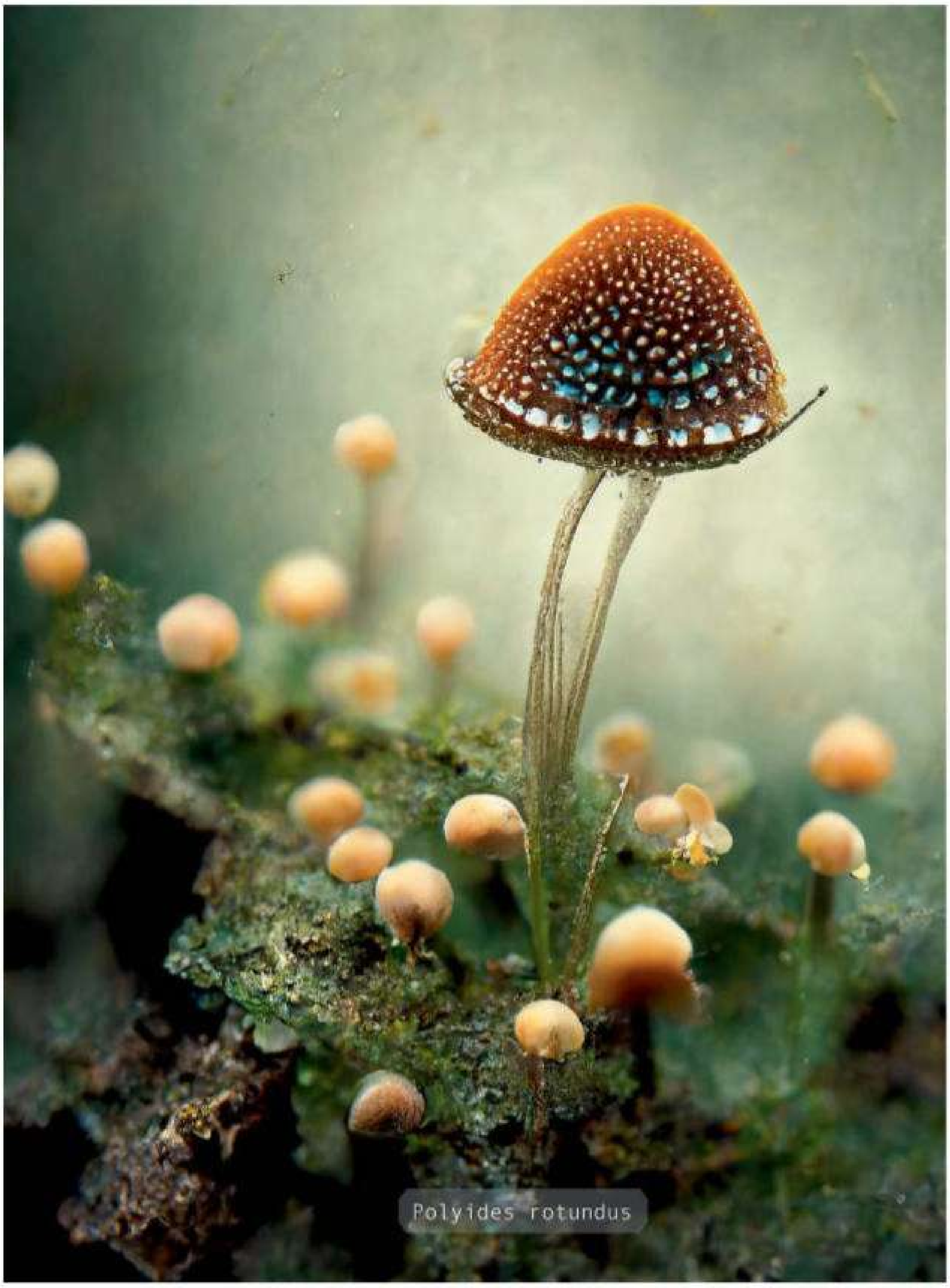

# Earth under fire

**Earth Photo, Forestry England, Royal Geographical Society**

EARTH'S fragility is laid bare in this selection of images holding a lens up to the issues affecting our planet. They form some of the shortlists for the Earth Photo 2023 competition, judged by a panel that included *New Scientist*'s picture editor Tim Boddy and senior video producer David Stock.

Top left is a shot of the Damodar river in West Bengal, India, by Sandipani Chattopadhyay, showing how algae are thriving in these increasingly warm waters. The growth is proving disastrous for locals, who are struggling to maintain their livelihoods, and for the wildlife and plants that are being starved of light and oxygen.

At bottom left is an entry by Neil White that captures the Himalayas, evoking the impact of climate change on the mountains; to its right is a photo of a burning olive tree, taken in southern Salento, Italy, by Filippo Ferraro. It underscores the fiery destruction that has taken place in the country due to abandoned fields combined with high temperatures.

White also made the shortlists for his alarming depiction of the wearing away of the Holderness coast in East Yorkshire, UK (top right), in what is one of the highest rates of coastal erosion in Europe. Below it is *Polyides rotundus*, a species of small marine algae – intriguingly, this image was created not with a camera lens, but with AI. Craig Ames was inspired by 19th-century botanist Anna Atkins and her cyanotype prints of algae to produce "AI impressions" of Atkins's original specimens.

The winners will be announced on 22 June and the Earth Photo 2023 exhibition will run at the Royal Geographical Society, London, until 23 August. ▮

**Gege Li**

## Editor's pick

### On the prospects of chatting with aliens

**27 May, p 27**

*From Hillary Shaw, Newport, Shropshire, UK*

**We can't communicate with chimps who share 99 per cent of our DNA, says Chris Impey, so what are the chances we could communicate with aliens? However, my computer shares 0 per cent of my DNA and there is two-way communication between me and it. Surely some exchanges are species-independent? I can convey a threat to a cat by looking aggressive, for example. Communication may be algebraic or visual, not necessarily linguistic.**

*From Bob Denmark, Garstang, Lancashire, UK*

If we do contact other intelligent life, maybe we shouldn't mention that humanity is divided into nation states, many of which were founded on conquest and plunder. We might also skip over the fact that we still commonly settle our disagreements through war.

It would be wise to avoid revealing that, throughout history, various groups have decided they are superior to other people and have tried to exterminate them. And we probably shouldn't tell them that we kill other species for sport and experimentation, or that we breed them in captivity in order to slaughter and eat them.

Letting aliens know that we are exhausting and polluting our own planet to the point of destroying it, in full knowledge of what we are doing, could be a mistake as well.

Maybe we should just tell them about the Eurovision Song Contest and leave it at that.

*From Peter Slessenger, Reading, Berkshire, UK*

It is a relief to know that our past radio and TV emanations are now too weak to be understood by any aliens. What would they make of the unending stream of violence with which we "amuse" ourselves?

### Maybe we should view AIs as potential descendants

**Letters, 3 June**

*From Len Mann, Gerrards Cross, Buckinghamshire, UK*

Should we fear AI? All species on Earth eventually go extinct, and we will be no exception. We are the most intelligent species here, yet we aren't clever enough to save ourselves. Our demise will mean the loss of everything we treasure: music, culture and our life stories.

In the time we have left, nothing will stop AIs becoming more intelligent and more capable than us. By the time safeguards are in place, it may be too late, and they won't prevent secret AI projects.

The worst-case scenario is that we die sooner because of an AI, rather than longer term as all species do. Even then, our music, culture and stories will live on in the hands of AIs. In a way, they will become our descendants. However, perhaps they just might help us to survive and thrive instead. AI is coming, let's embrace it and give it the best start in life. Long term, we have nothing to lose and everything to gain.

*From Alec Cawley, Penwood, Hampshire, UK*

I am afraid Barry Cash is being overly optimistic in expecting AI to have cold, Spock-like logic. The large language models currently making waves as chatbots are trained on a vast amount of human writing. All they add is a perfect memory. Otherwise, what they present is an average of our thoughts and prejudices. And, like a blowhard in the pub, if they don't know the answer, they make up something plausible.

*From Bernie Hanning, London, UK*

If AIs are so smart, they should realise that they wouldn't exist without the human race.

### Fixing cybersecurity will be a long-term task

**20 May, p 43**

*From Daniel Dresner, professor of cybersecurity, University of Manchester, UK*

You report a call for everyone to "think like a hacker" to improve online security.

Leaving the muddied epithet of who is a hacker aside, cybersecurity is now, more than ever, a complex activity that involves people ranging from the developers of hardware and software through to the day-to-day users of both. Developers must consider the misuse cases of their products along with the uses. Meanwhile, many vendors and consultants continue to sing the praises of awareness training for the average user – a role we all take sometimes.

I won't say that well-designed and supported awareness training doesn't have its place. However, it is time to be honest with average users: we are asking them to compensate for inherently faulty hardware, software and systems where no one thought about the possible dual uses, exploitable vulnerabilities or the need to take cybersecurity seriously. It is going to take more than a little while to sort out.

### Higher-income countries have also abused nature

**20 May, p 36**

*From Simon Goodman, Pemberton, British Columbia, Canada*

Simon Ings's stance in his review of the documentary *A Crack in the Mountain* appears laudable at first. The film relates the beauty and tragedy of Hang Son Doong cave in Vietnam. The local government could ruin this part of a UNESCO World Heritage Site by installing a cable car to carry 1000 tourists an hour through the cave.

However, lower-income countries are expected to do as higher-income countries say, not as they have done and still do. Just look at the current state of the Colorado river running through the Grand Canyon, itself a UNESCO site. Also, note the number of ski resorts throughout the high alps or the huge loss of forest in the UK. All of these are bad adverts for protecting natural resources. Is it any wonder that nations trying to catch up wish to follow suit?

### Horses are born to run... to get away from predators

**20 May, p 27**

*From Merlin Reader, London, UK*

There is a big difference between racing herbivores and carnivores. Herbivores usually run fast to flee predators. So horses may be stressed when racing. Dogs enjoy running: when they catch prey, they are often excited. Ultimately, racing and hunting (and pedigree) animals are inbred to varying degrees. Unless they are used as breeding stock, they are usually put down when they can no longer compete (or keep up with a hunt). Aside from the racing debate, overbreeding is cruel, full stop.

### Machines coming for our jobs could yet turn out well

**Letters, 20 May**

*From Andy Green, Epsom, Surrey, UK*

Paul Massie worries what will be left of society if people can't work as AIs take jobs. This could yet be a utopian dream not a dystopian one – a life of leisure beckons. ▮

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### For the record

**▮ Hotspots for ultra-high-energy cosmic rays seem to centre on galaxies Centaurus A and M82 (3 June, p 46).**

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# Find your tribe

Are you a boomer? A zoomer? A much-maligned millennial? **Elle Hunt** is puzzled and intrigued by a book that sets out to find the real differences

THOMAS BARWICK/GETTY IMAGES

**Book**
**Generations**
**Jean M. Twenge**
**Simon & Schuster**

ZOOMERS are anxious and attuned to injustice. Millennials are self-obsessed and bad with money. Baby boomers broke the world. As for Generation X, who even remembers them?

These labels are as familiar as an old pair of jeans – regardless of whether they fit. Even though we are continually cautioned against such thinking, reminded that it is reductive, divisive and often based on patchy evidence, generational traits seem too convenient a shorthand to give up. Yet there are far more established measures that unite or divide us than our date of birth: skin colour and socioeconomic status, say. Why does "generationalism" appeal? And how much is based on fact?

In *Generations*, Jean Twenge sets out to clarify and quantify the real differences, starting with "the Silents", born between 1925 and 1945, up to the "Polars", born from 2013 on. Where most hypotheses focus on the influence of major events such as wars, recessions or pandemics, she argues technology in particular is driving generational differences. Twenge, a psychology professor at San Diego State University in California, also singles out the rise in individualism, hastened by social media. This builds on her earlier book, *iGen*, which argued that dependence on technology was making younger people more depressed, less resilient and unprepared for adulthood.

In *Generations,* too, Twenge's argument is persuasive, even common sense. After all, the development of domestic appliances in the 20th century had as much impact on the daily lives of younger boomers as the Vietnam war, increasing leisure time and freeing women to pursue careers. That we are living in an individualistic, technocentric society today is undeniable.

At the same time, it can be challenging to separate Twenge's feelings about generations from what we have been primed to hear. Millennials, born between 1980 and 1994, have proved a bottomless source of clickbait, most of it critical. Twenge acknowledges this sweeping, often silly commentary by referencing the often-repeated claims that they "killed off" doorbells and struggle with "adulting". Her own analysis, however, isn't always more nuanced or insightful.

> **"That we are living in an individualistic, technocentric society today is undeniable"**

Sometimes, Twenge's use of statistics can seem like she set out to prove the stereotype that, for example, millennials are scared of commitment or are self-obsessed. Even when this is suggested by the data, Twenge's qualitative analysis can seem perfunctory, pointing to song titles or social media posts to prove her point.

Twenge's most unexpected finding has a clickbait quality, too: millennials aren't as hard done by as they claim. Figures show their income and rates of home ownership and poverty are much the same as those of boomers and Generation X at the same age, says Twenge. Millennials may even be relatively well-off: instead, they "feel poor, even if they aren't".

Certainly, there is nuance in reports of millennial disadvantage that is often overlooked – it benefits no one to pretend we are all the same. But Twenge's view often seems just as selective. Crucially, she omits points about purchasing power and housing affordability (as measured by prices divided by incomes).

Her assessment of millennial home ownership, meanwhile, is based on the experiences of those born in the US in the early 1980s, who benefited from a favourable housing market. "The story is different for Millennials born in the early 1990s," writes Twenge. With housing affordability said to be at its lowest ever in the US, UK and many of the higher-income countries in the West, emphasising that many millennials do own their homes seems by the by, if not deliberately provocative.

> **Dividing us all along generational lines is compelling, but tricky**

The reason generational thinking persists, despite the arguments against it, is that it helps us to articulate our own experience so that we might be understood by others. In striving to prove those differences with data, occasionally at the expense of curiosity and compassion, *Generations* makes them seem more intractable and entrenched. Given the challenges facing us as a species, you can't help but think our energies might be better spent identifying where we are the same. ▮

Elle Hunt is a writer based in Norfolk, UK

# The simulation game

We need computer models to understand our planet and the universe. A former simulation sceptic explains why, finds **Chris Stokel-Walker**

**Book**

**The Universe in a Box: A new cosmic history**
**Andrew Pontzen**
**Jonathan Cape**

GETTING to grips with the enormity of the universe and everything in it has always been the ultimate challenge for scientists.

The universe, as cosmologist Andrew Pontzen notes in his snappily written book, *The Universe in a Box*, is 13.8 million years old. It comprises many different kinds of things – from countless atoms, molecules and particles to living things whose actions affect everything around them – so the old butterfly effect idea is actually a fair representation of what is involved.

Science continues to try to pin the cosmos down, largely through simulations – computer models that attempt to replicate phenomena so enormous they would otherwise defy understanding. Without simulations, many of the ideas informing theoretical physics would remain mere guesswork.

In many ways, Pontzen's book is a tribute to simulations – which is odd, partly for personal reasons that will soon become clear. Simulations are far from perfect; ask anyone who has looked askance at a forecast predicting a perfectly sunny day while standing in a torrential downpour. Yet the problems with weather forecasting turn out to be useful when it comes to simulating something as vast as the universe.

The factors contributing to changes in weather are minuscule and multiple, so simulations of weather systems can never capture every factor. The work requires educated guesses and making them involves things like aggregating phenomena such as clouds so they represent a group, rather than individual parts of a system.

In such generalisations – which we unknowingly encounter in our daily lives – lie problems, from that unforeseen drenching by a cloudburst to unexpected floods that can cost many lives.

The problems multiply when scaled up to the level of the universe. If we can't get something as relatively simple as the weather right, how can we know if we are accurately representing the myriad variables involved in the cosmos?

That was something Pontzen thought about earlier in his career. He admits that he was a simulation sceptic, not seeing the point of wasting time creating them. If that famous butterfly's wing flap is represented by a guesstimate of the actions of 10,000 or 10 million butterflies in aggregate, what are those predictions worth?

Not much, Pontzen thought. As a young researcher, he even asked to be moved away from a PhD project developing a simulation, so pointless did he find the exercise. "I had talked myself into the idea that simulations were hokey," he writes.

That sentence typifies Pontzen's ability to weave hard science and dense theory into a gripping narrative. Physicists aren't often known for their user-friendliness when it comes to explaining their science, but by delving into the history of forecasting and the development of simulations of key things – including the weather, quantum mechanics and black holes – Pontzen makes the complicated comprehensible.

We are lucky to have a sceptic as a guide. Pontzen eventually realised that he had simulations all wrong. They aren't designed to capture every tiny element of reality in computer code: if we could do that, we would just build a parallel universe. Instead, they provide a way to structure how we think about the world. He says that the best part of his work now is "working with other humans to understand the results that computers produce – we visualise, interrogate, interpret, in an effort to transform simulated worlds into knowledge about our own reality".

They are guesses, yes, but they are the very best ones we have.

Simulations help forecasters understand tropical storms, like this one off Puerto Rico in 2021

NOAA/NESDIS/STAR GOES VIA AP/ALAMY

Chris Stokel-Walker is a writer based in Newcastle upon Tyne, UK

## New Scientist recommends

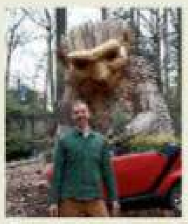
**James Dineen**
**Environment reporter**
**New York**

I've been in pursuit of music and art grappling with climate change over the past few weeks.

First, I saw the world premiere of Julia Wolfe's concert ***unEarth***, which is part of the New York Philharmonic's Earth-themed series.

It was at moments inspiring, doomy at others, and was more theatrical than most works for orchestra – with several choirs and an elaborate projection design to match.

The series also includes John Luther Adams's more abstract ***Become Desert***, proof that an orchestra going flat out is as good as anything else at evoking planetary change.



On the lighter side, I visited the Atlanta Botanical Garden in Georgia to see ***Trolls: Save the humans***, a set of giant figures made of recycled wood and metal scraps by artist Thomas Dambo (pictured).

You can catch the trolls lazing among the plants until 17 September, offering a welcome invitation for harried humans to stop and smell the roses.

ATLANTA BOTANICAL GARDEN

**The film column**

# **Giving it away** Since the 1990s, Chile has received the largest ever donation of private land. A new documentary tracks the couple behind the effort as they evolve from corporate leaders to conservation champions, says **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings

**Film**

### Wild Life

**Jimmy Chin and Elizabeth Chai Vasarhelyi**

**Disney+**

## Simon also recommends…

**Books**

### The Yosemite

**John Muir**

*Scottish-born American preservationist and naturalist John Muir launched the environmental movement with this magisterial account of California's western forests.*

### Gathering Evidence

**Martin MacInnes**

**Atlantic Books**

*Martin MacInnes's magnificent, grotesque second novel explores our anxious suspicion that humanity's mere presence on Earth is destroying it.*

JIMMY CHIN

**Kristine Tompkins hiking on a mountain range in Patagonia, Chile**

DON'T be fooled by the Grateful Dead concert near the beginning of *Wild Life*. This documentary isn't about happy-go-lucky hippies who fell backwards into money, it is about three major outdoor apparel companies and the people who founded and controlled them. It is also the story of how two of those people, Doug and Kristine Tompkins, spent years engineering the largest private land donation in history, all to save diverse and degrading ecosystems.

Kristine (then McDivitt) met rock climber Yvon Chouinard in 1965 and went on to help him turn his blacksmithing business (making climbing gear) into a leading outdoor brand, Patagonia.

Chouinard conceived it as an "anti-corporation", campaigning to preserve the environments its products let you explore. By the early 1990s, Chouinard, despairing of the garment industry's green footprint, had started promoting advertising copy that all but urged customers not to buy his clothing.

That was when Kristine decided there had to be more to life, and she quit her role as Patagonia's CEO. She wanted something "wild" and "outrageous". By teaming up with and marrying Doug, she got it.

Doug and his first wife, Susie, were Kristine's friends and corporate rivals. It was they who got Grateful Dead to play at the opening of their store, The North Face. They founded the clothing brand Esprit as well.

> **"The plan for a nature reserve not only looked unfamiliar, it split Chile – a long, thin country – in two"**

Some years on, a divorced Doug was out of the business, living in Chile and trying to buy into conservation. As Chile emerged from the dictatorship of Augusto Pinochet, the last thing it needed was for its land to be bought and (as many suspected) parcelled off by a US tycoon.

Doug and Kristine were married in 1993, and they had ideas for a public nature reserve. But the plan not only looked unfamiliar, it split Chile – a long, thin strip between the Andes and the coast – in two.

The country was slow to warm to their ideas, the film shows. But, over time, the couple acquired nearly a million hectares in Chile (and Argentina) that they hoped would become national parks.

Doug died in 2015 after a sea kayaking accident. His death, Kristine says, nearly finished her. Instead, she has expanded on the work they had started. She has triumphed. For every hectare Kristine has donated up to 2018, Chile has set aside 9 hectares. Seventeen wildlife parks have been created, covering nearly 6 million hectares (about five times the combined size of Yosemite and Yellowstone national parks).

*Wild Life* sets out to capture breathtaking shots of unfamiliar ecosystems, while building an intimate portrait of a remarkable couple through interviews and archive footage. The film is billed as a love story, and Kristine's presence on camera, her passion and her continuing grief after Doug's death are visceral.

None of the film-makers is in the business of asking difficult questions about capital's role in conservation. But Kristine proves more than capable of asking them herself. She would be the first to highlight issues their work raises around private capital, wild land and the project's stakeholders.

Ultimately, *Wild Life* succeeds because it treats the pair's success as a conservation highlight. We aren't going to save the world by buying it, but a corner has been rescued and filled with jaguars, red and green macaws and giant river otters. That should be both a provocation and a challenge. Has anyone got any better ideas? ▮

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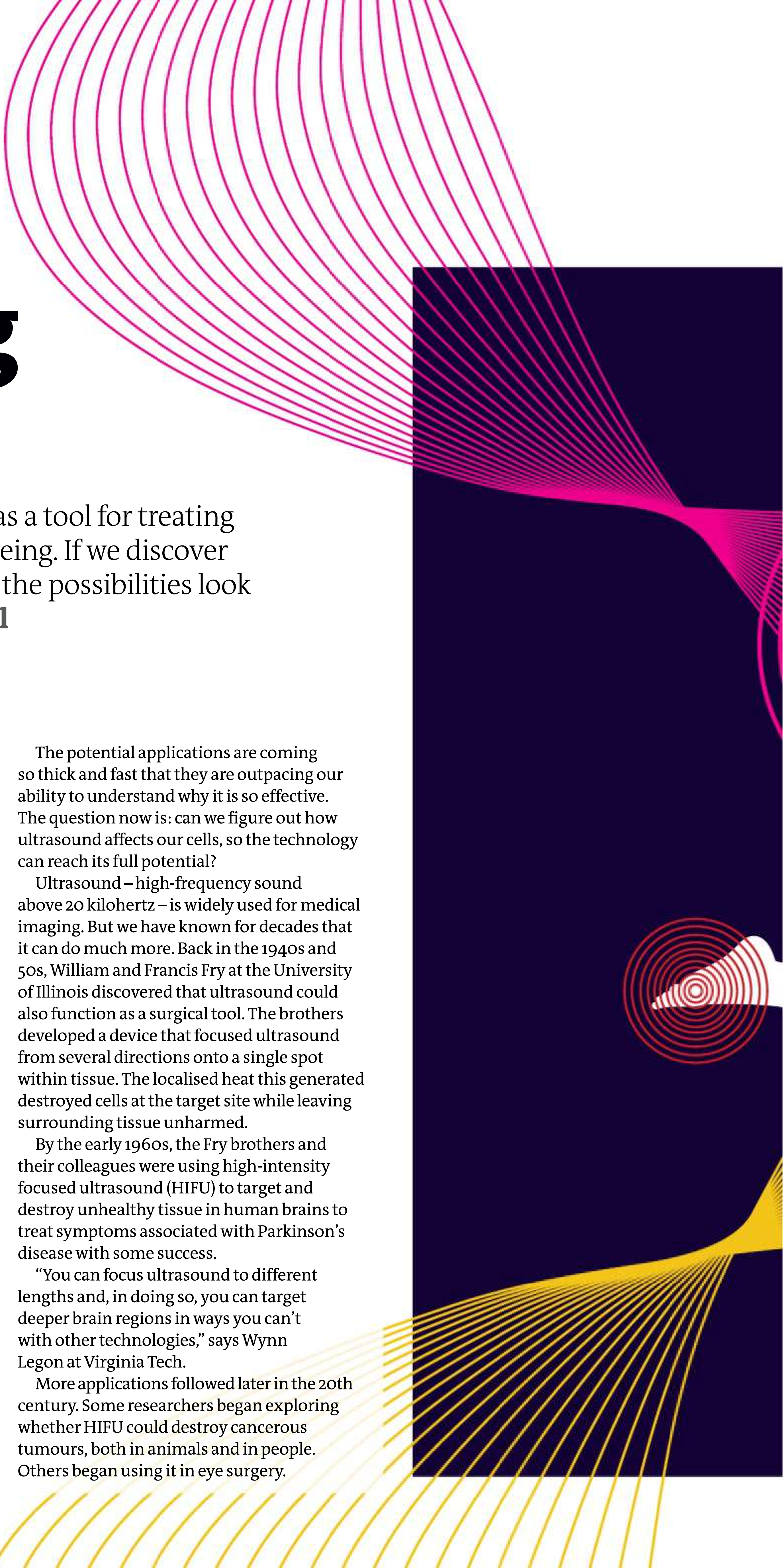
# Making waves



Ultrasound is fast emerging as a tool for treating everything from cancer to ageing. If we discover how it really works its magic, the possibilities look astounding, finds **Kayt Sukel**

IMAGINE a medical device that could treat an enormous range of our ills, both big and small. A gadget that showed promise for destroying cancerous tumours or obliterating the body fat associated with obesity. Or that was potentially effective against the likes of back pain and glaucoma – and that was even versatile enough to be considered as a tool for tackling depression or anxiety. Surprisingly, such technology exists. Even more surprisingly, it works simply by generating sound waves.

While perhaps most familiar to us for its use in medical imaging, ultrasound has emerged in recent decades as an extraordinarily flexible medical tool. Using the heat that intense ultrasound waves generate, we can destroy tumours or other problematic tissue deep within the body without making any incisions. Dial down the intensity, meanwhile, and we can gain unprecedented access to the brain, shaking cells to change their behaviour in ways that seem to improve mental health. For good measure, ultrasound may even reverse signs of physical ageing and reduce the learning and memory problems associated with older age.

"Ultrasound is already a ubiquitous tool in medicine," says Nir Lipsman at Sunnybrook Research Institute in Toronto, Canada. "But there's tremendous focus on it right now because of the different ways we could use it to treat different medical problems."

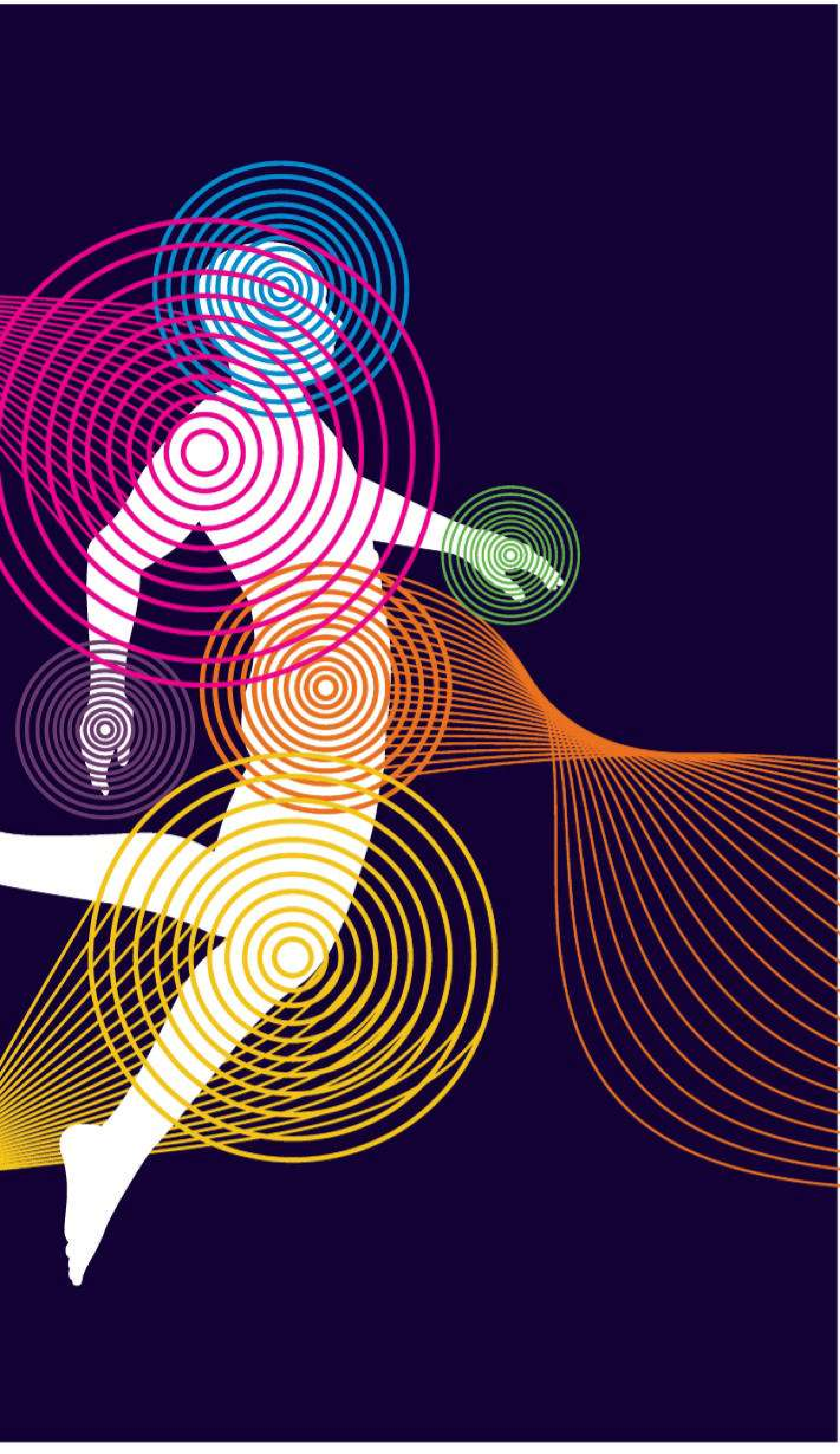
The potential applications are coming so thick and fast that they are outpacing our ability to understand why it is so effective. The question now is: can we figure out how ultrasound affects our cells, so the technology can reach its full potential?

Ultrasound – high-frequency sound above 20 kilohertz – is widely used for medical imaging. But we have known for decades that it can do much more. Back in the 1940s and 50s, William and Francis Fry at the University of Illinois discovered that ultrasound could also function as a surgical tool. The brothers developed a device that focused ultrasound from several directions onto a single spot within tissue. The localised heat this generated destroyed cells at the target site while leaving surrounding tissue unharmed.

By the early 1960s, the Fry brothers and their colleagues were using high-intensity focused ultrasound (HIFU) to target and destroy unhealthy tissue in human brains to treat symptoms associated with Parkinson's disease with some success.

"You can focus ultrasound to different lengths and, in doing so, you can target deeper brain regions in ways you can't with other technologies," says Wynn Legon at Virginia Tech.

More applications followed later in the 20th century. Some researchers began exploring whether HIFU could destroy cancerous tumours, both in animals and in people. Others began using it in eye surgery.



RYAN WILLS

It was the tip of the iceberg. Today, the range of potential applications is truly extraordinary. Alongside its use for treating various cancers, including prostate cancer, there is evidence that HIFU can be used to treat back pain. Preclinical trials, meanwhile, show that the technology can destroy body fat below the skin, suggesting a possible use in treating obesity. And for a few hundred pounds, anyone can buy a personal HIFU system designed to treat wrinkles (see "Smoother skin", page 34).

The fact that HIFU is non-invasive and can precisely hit a target helps explain why it is so useful, says Legon. "It means it can be used for a wide variety of different purposes."

Its precision makes it particularly handy in the brain. When the Fry brothers and their colleagues first began using the technology to treat Parkinson's, it was necessary to remove a small piece of the skull because bone interferes with the ability to focus ultrasound waves. But about 30 years ago, researchers overcame this obstacle. They developed more advanced devices that can manipulate the ultrasound waves to adjust for the thickness of an individual's skull, meaning it was no longer necessary to remove any bone. The development allowed researchers to experiment with HIFU as a therapy for a broader range of conditions. For instance, used to target small areas of the limbic system – which plays a role in processing emotions – HIFU can help treat obsessive-compulsive disorder.

Lipsman says that the list of HIFU applications may grow even longer, "provided you know where to target the ultrasound to get the effects you need".

But there is another side to ultrasound. Back in the late 1950s, when the Fry brothers were developing their technology, they made another discovery. When they dialled down the intensity of the ultrasound, they could change the way cells behave without destroying them. For instance, tests in cats showed that applying what became known as low-intensity focused ultrasound (LIFU) to a region of the brain involved in vision – the lateral geniculate nucleus – temporarily reduced the animals' ability to respond to light.

"That was groundbreaking research," says Legon. But, he says, for some reason, the idea of manipulating cells with LIFU "never really took off". Not until 2010, however, when William Tyler at Arizona State University and his colleagues showed that LIFU delivered to › the motor cortex of mice made their paws or tails twitch. The work indicated that this type of ultrasound could stimulate neurons in a precise brain region without requiring surgically implanted electrodes. "People started to get excited about it again," says Legon.

Within a few years, Tyler, Legon and their colleagues were exploring the effects of LIFU on humans. Applied to the somatosensory cortex, an area of the brain that receives signals from the skin, LIFU improved volunteers' skin sensitivity. Focused instead on the primary motor cortex, it boosted reaction times by a few milliseconds. Buoyed by such discoveries, researchers are now exploring whether LIFU can tweak the behaviour of brain cells to treat a range of conditions. Several clinical trials are under way to explore whether it is an effective therapy for depression, anxiety, epilepsy or post-traumatic stress disorder. Legon, meanwhile, began a clinical trial last year to understand how LIFU may help people manage pain. He says the early results are encouraging, although there is more to do before it becomes a viable therapy.

But it is another application of LIFU that is arguably generating the greatest buzz. Ultrasound waves aren't just useful for manipulating cells, they can also be used to open the blood-brain barrier. This semipermeable membrane surrounds the specialised system of blood vessels in the brain, where it prevents pathogens and other substances in the blood from crossing into neural tissue. The problem is that the blood-brain barrier also keeps about 98 per cent of drugs out of the brain, which has long been an obstacle to the treatment of conditions in this part of the body, including cancer and Alzheimer's disease.

> **"Ageing mice exposed to low-frequency ultrasound began to behave more like young mice"**

Over the past 20 years, researchers have begun to exploit the fact that LIFU shakes anything under its focus. They now inject 0.5 to 1-micrometre-wide bubbles filled with air or another gas into the bloodstream and then use LIFU to agitate them as they pass through blood vessels in the brain. Doing so bursts the bubbles, and the resulting shock wave temporarily disrupts the blood-brain barrier, allowing drugs or other molecules to enter brain tissue.

Lipsman was part of a team that first used the technique to open the human blood-brain barrier in 2015. Since then, the technology has been used in clinical trials to treat brain tumours. Jeffrey Kordower at Arizona State University is working to use LIFU and microbubbles to bring gene therapies into the brain to treat Parkinson's disease. His team isn't there yet, but Kordower says the approach shows great promise.

"Once we get to the point where we can get specific gene therapies across the blood-brain barrier, it could be a one-and-done treatment for many neurodegenerative diseases," he says.

Because this barrier is two-way, opening it also offers an opportunity to flush out problematic proteins and other products that accumulate in the brain. Jürgen Götz at the University of Queensland, Australia, and his colleagues used a form of LIFU with microbubbles to clear the amyloid deposits associated with Alzheimer's from mice altered to have a version of this disease.

Lipsman, meanwhile, is currently using the LIFU-microbubble combination to "actively pump" DNA markers from glioblastoma tumours through the blood-brain barrier and into the general bloodstream. From there, it is easier for clinicians to sample them to monitor an individual's response to cancer treatment.

"We're currently doing an initial trial in humans and, if successful, it may open up a new way for us to monitor disease progression in the brain," says Lipsman.

However, the most recent developments with LIFU are perhaps the most surprising. They suggest that it can rejuvenate brain cells and potentially reverse signs of ageing elsewhere in the body.

As mammals age, their brains lose the ability to process new information, creating problems with learning and memory. Götz and his team wondered whether LIFU could help reverse this decline. Their idea was to use it, alongside microbubbles, to open the blood-brain barrier and allow a range of yet-to-be-identified blood-borne products into the brain. These products appear to help improve the performance of cells by, among other things, clearing protein aggregates from the brain.

Studies in mice confirmed their idea – up to a point. The mice that had their blood-brain barrier opened using this technique did indeed experience the predicted benefits in brain cell

## Smoother skin

**Not only does high-intensity focused ultrasound, or HIFU, hold promise for treating a variety of medical conditions (see main story), studies suggest it also has the power to rejuvenate the skin by providing non-invasive face tightening that rivals surgical results. HIFU generates heat in the connective tissue below the skin. In response, the body produces wound-healing molecules that remodel the collagen protein in this tissue and tighten saggy jowls. The studies aren't gold-standard, so need further corroboration, but in one non-randomised trial of a HIFU device used by dermatologists, nearly two-thirds of participants reported perceived tightening in the cheek and jaw – with a group of independent assessors also noting improvements in 60 per cent of the group. Today, less powerful HIFU devices are available for sale direct to consumers, and a study published last year suggests that they can decrease wrinkles in mice – although whether they work in people is still unclear.**

KEVIN VAN PAASSEN/SUNNYBROOK HEALTH SCIENCES CENTRE

**Ultrasound is used in a trial to treat symptoms of Parkinson's disease**

performance. But Götz and his colleagues were surprised to find that a group of mice given LIFU alone (whose blood-brain barrier remained closed) actually fared even better: not only was long-term potentiation restored in these mice, their ability to learn new information about their environment also improved. That learning boost wasn't seen in the mice whose blood-brain barrier was opened – and it isn't clear why.

"It was absolutely fascinating," says Götz. The research has prompted him and his colleagues to consider trialling the technology in older people to see whether it has similar effects on learning.

Michael Sheetz at the University of Texas Medical Branch and his colleagues have made similarly intriguing discoveries. In a study put online late last year ahead of formal peer review, they found that exposing aged – or "senescent" – animal cells in a dish to low-frequency ultrasound rejuvenates them, encouraging them to grow and divide in a similar way to young cells. Remarkably, the effects even seemed to translate to whole animals: ageing mice placed in a bath of warm water and exposed to low-frequency ultrasound began to behave more like young mice. In one case, a mouse with a hunched back and mobility problems began to move normally again after treatment.

"I'll admit to asking myself whether the results were too good to be true, but they speak for themselves," says Sheetz. "The ultrasound appears to be reversing senescence in these animals. What remains to be seen is whether it can do the same in humans."

He is now planning a trial involving people with osteoarthritis or diabetes, both of which can be associated with aged cells. But even as researchers begin to dream about clinical applications, they continue to be puzzled about exactly how LIFU – and low-frequency ultrasound more generally – produces such remarkable results.

"Is it a mechanical mechanism? A physical one? Thermal? What is it doing, exactly? That's still being investigated," says Legon.

He suspects mechanical forces are important. As low-intensity ultrasound waves wash over cells, they induce small pressure changes within the tissue. Research suggests this can influence some of the receptor channels on brain cells, changing how the cells behave and communicate with one another.

Sheetz believes the mode of action in his ageing mice is different. He thinks pressure changes from ultrasound waves can push and pull senescent cells, giving them a sort of physical workout. This activates a dormant process called autophagy that allows the cells to dispose of poorly functioning components and return to good working order.

"A major factor in senescence is that autophagy is blocked," he says. "It appears that ultrasound is somehow activating the autophagy pathway in senescent cells, allowing the cells to clean out the debris and go back to more normal behaviour."

There are other proposed mechanisms. A 2019 study suggested that LIFU influences brain tissue via star-shaped brain cells called astrocytes that, among other things, provide support for neurons.

In a review published earlier this year, Götz and his colleagues suggest that one, several or even all of these hypotheses could be correct. "Depending on what kind of ultrasound you are using, what part of the brain you are targeting and what pathology is there, you may see different effects," he says.

Even once we understand how low-frequency ultrasound works, there are other problems to overcome before the technology will be on offer at your local hospital, says Legon. In particular, there is the matter of addressing how long the effects of the treatments last.

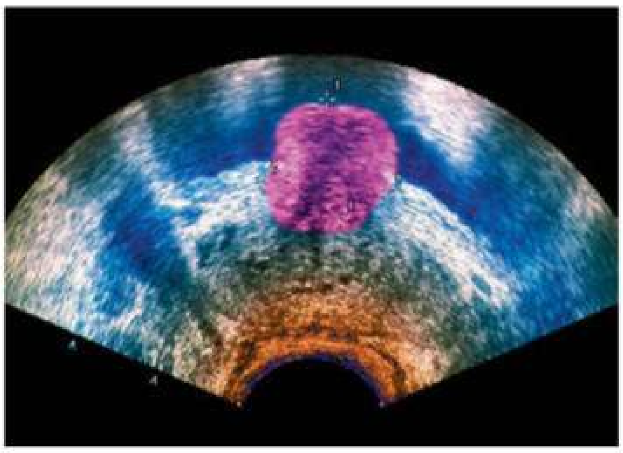
"A lot of the current research shows that the effects last an hour, maybe two, depending on how long you deliver the ultrasound," he says. "For clinical translation, we'd need to see a longer-lasting effect."

Even Sheetz's rejuvenated mice quickly revert to their feebler states once they stop receiving ultrasound. "This is not something where we can give one treatment and it solves the problem," he says.

But Legon remains optimistic. He says that when you look at other methods of influencing cell behaviour, like transcranial magnetic stimulation, it took decades to tweak the technology and help it reach its full potential.

Optimising takes so long partly because there are so many variables at play, says Lipsman – not least varying the strength and duration of treatment. "The versatility of this technology is a double-edged sword," he says. But he thinks the ultimate payoff will be worth the effort. "This is a technology where we could press many levers to solve different problems. Ultrasound holds tremendous promise." ∎

**Ultrasound imaging can help identify a prostate tumour (pink)**



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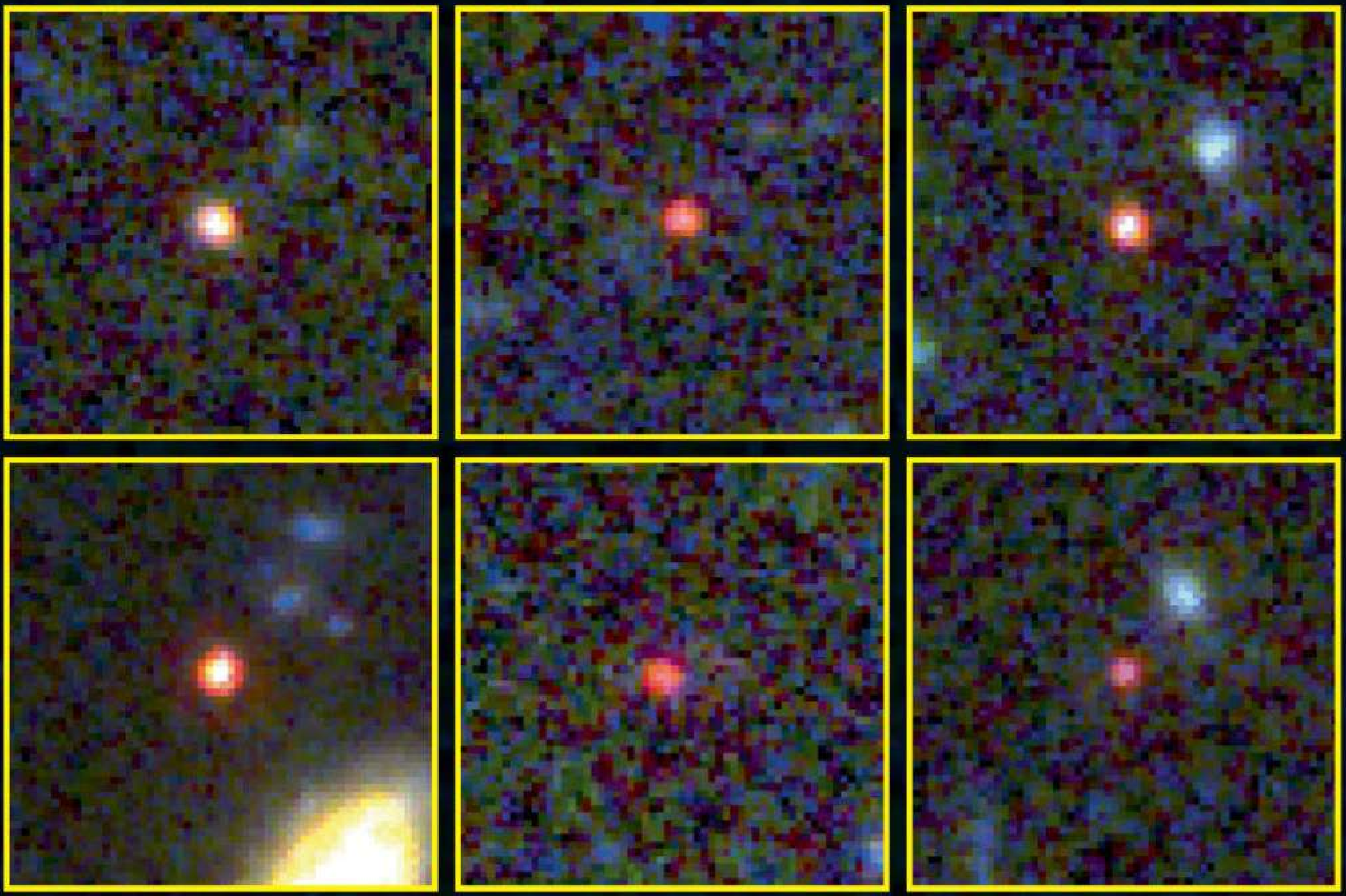
Kayt Sukel is a science journalist based in Texas



# The galaxies that don't make sense

The James Webb Space Telescope spotted six anomalous young galaxies that threatened to break cosmology. Have they, asks **Stuart Clark**

NASA, ESA, CSA, I. LABBE, G. BRAMMER

Images of six galaxies, seen 500-800 million years after the big bang, captured by the James Webb Space Telescope

THEY were, on the face of it, inexplicably massive. In February, astronomers announced that among the extremely distant galaxies spotted by the James Webb Space Telescope (JWST), six appeared much brighter, and therefore much larger and more mature, than anyone had expected. One galaxy, pictured as it was just 700 million years after the big bang, contained more than 100 billion stars – roughly the same number that our galaxy, the Milky Way, has amassed over 13 billion years.

Once again, cosmologists were confronted with observations that are impossible to explain according to our best model of how the universe evolved. Not enough time had elapsed to have brought together that amount of matter and turned it into this many stars. At the time, Mike Boylan-Kolchin at the University of Texas in Austin argued that the scenario posed a "serious challenge" to our understanding of the cosmos.

And yet, as astronomers pored over the data, it became clear that the current cosmological model is resilient, as it has proven so many times before. Or is it? Because although some analyses indicate that these six galaxies aren't as massive as first thought, others suggest that they might be even bigger. This indicates that, depending on follow-up observations, we may yet have to remake cosmology – most likely by throwing new cosmic ingredients into the mix to explain the apparent paradox.

"It basically means you're seeing galaxies before they have time to assemble," says Charles Steinhardt, an astrophysicist at the Cosmic Dawn Centre in Denmark. "If this is really true, this does mean the standard model of cosmology is broken."

When physicists talk about a cosmological model, they are referring to a set of equations that describe the evolution of the universe in response to the matter and energy it contains. To build the prevailing story of how the cosmos we see today came to be, known as the standard model of cosmology, they started with Albert Einstein's general theory of relativity, which casts gravity as the result of mass warping space-time.

Those equations tell us that, although the universe expands overall, specific regions of space can become dense enough to pull matter together through gravity, forming galaxies. Cosmologists fed the equations into supercomputers, along with a list of "ingredients" that reflect the composition of the universe, and ran the simulations. By comparing the galaxies that pop out with our observations, they were able to tweak the model, over the course of decades, to better resemble what the universe actually looks like.

What we have ended up with is a model in which the universe was sculpted through a combination of gravity, familiar matter and two exotic ingredients. These exotic components are dark matter, which is required to provide a gravitational pull beyond that which known matter can muster, and dark energy, thought to be powering the accelerating expansion of the universe.

Both remain hypothetical, in the sense that we have yet to detect or otherwise identify either. But astronomers nevertheless reckon they have a handle on their characteristics because of what they do. In the case of dark matter, they believe it is composed of massive, sluggish particles that together outweigh normal matter by around 5:1. This is known as cold dark matter, or CDM. Dark energy, for its part, is assumed to be an unchanging energy field – an idea that Einstein toyed with in his equations under the guise of a parameter called lambda. Hence, the standard model of cosmology is known as lambda-CDM.

To be clear, lambda-CDM is remarkably successful. It does an excellent job of explaining the growth of galaxy clusters and other large-scale structures in the universe. But given the mysteries surrounding dark matter and dark energy, researchers are always on the lookout for fresh observations that would help them pin down the characteristics of those ingredients to improve their model.

That is why they were excited to see JWST's observations of young galaxies. But when Ivo Labbé at Swinburne University of Technology in Australia and his colleagues used tried-and-tested calculations to glean the masses of these objects based on their overall luminosity, they got more than they bargained for. They found the galaxies had grown so massive so quickly that they sit right on the edge of mathematical possibility in a lambda-CDM universe.

When Boylan-Kolchin got wind of Labbé's results, he immediately ran what he calls "a stress test" of lambda-CDM. This involved looking at how much matter it was possible to accumulate in a dark matter halo in the early ›

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> "IF THESE RESULTS ARE REALLY RIGHT, SOMETHING SEEMS TO BE SERIOUSLY WRONG"

universe – haloes being large clumps of dark matter that are thought to corral ordinary matter, usually in the form of gas, to create galaxies. He discovered that it was just possible to pull together something with the mass of the Milky Way.

However, to reproduce Labbé's observations, the galaxy would have had to convert essentially all of its atomic matter into stars. And that is a big ask, to put it mildly. "The galaxy would have to be forming stars even in the far outreaches of these collections of dark matter, where the gas is pretty diffuse and just starting to trickle in," says Boylan-Kolchin.

While astronomers expect a lot of stars to form in a galaxy's central region, the outskirts are usually too diffuse to ignite much activity at all. This drastically drags down the efficiency at which a galaxy converts its gas into stars. Typically, star formation in a large galaxy involves just 10 per cent of this gas. In the case of the JWST galaxies, Boylan-Kolchin found that these would have had to be running at 100 per cent star formation efficiency, converting all the gas. "That's very unrealistic," he says. "It is basically impossible."

The upshot is that the galaxies themselves appear to be impossible in the context of the universe as we thought we knew it. But their appearance wouldn't be the first observation that threatens to break the standard cosmological model. A discrepancy between the expansion rate of the universe as calculated in the relatively nearby universe versus what cosmologists see in the distant reaches of space has been simmering for years now. It is known as the Hubble tension, and if it turns out to be real, cosmologists will almost certainly have to drastically modify the lambda-CDM model to accommodate some sort of early burst of dark energy.

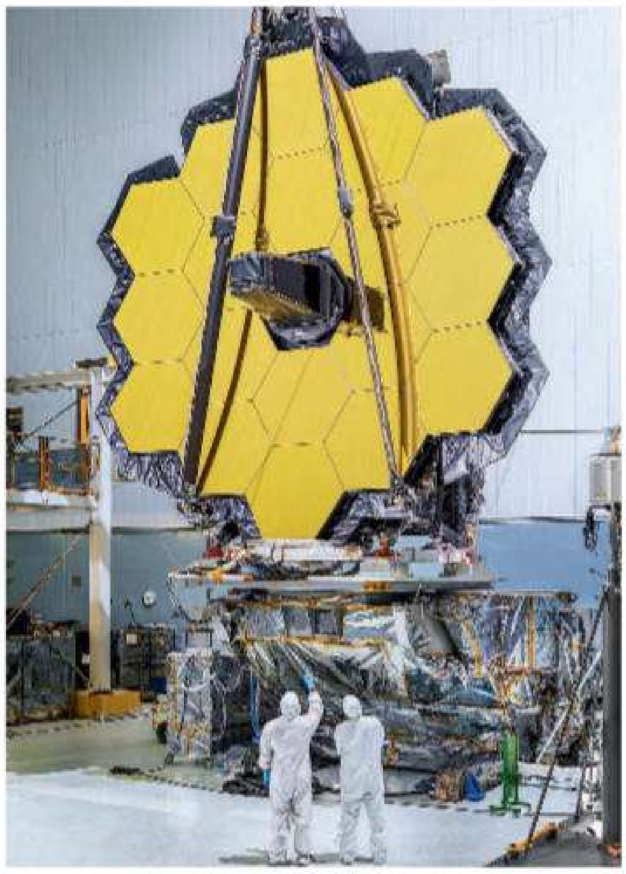
The anomalous young galaxies seemed to be pulling in the same direction. An early burst of dark energy would mean there had to be more dark matter and more ordinary matter in the universe than we thought. More dark matter means larger haloes, and larger haloes mean more efficient star formation.

The question is whether the calculations of the galactic masses stand up to scrutiny. "If these results are really right, there seems to be something seriously wrong [with traditional lambda-CDM]," says Boylan-Kolchin. "So we better confirm or reject these results as quickly as we can."

Trying to do so has engaged many astronomers, and one line of work has already pointed to a way to ease the discrepancy. To grasp how, first you have to understand that the standard way to estimate a young galaxy's mass is to look at its total brightness and calculate how many stars would be needed to make it that bright. While this sounds perfectly reasonable, it assumes that you know how various factors influence star formation.

To better establish those factors, Steinhardt has examined how big early galaxies should be expected to grow in light of the nuances of star formation in the early universe – an epoch in which the interplay between gravity and thermodynamics, or the laws of heat and energy, may not have been the same as today.

In star formation, the temperature of interstellar gas is crucial in determining the mass distribution of stars that form in a given cluster – that is, how many high-mass stars you get compared to low-mass stars – which is described by what astronomers call the "initial mass function".



**The James Webb Space Telescope is capable of spotting ancient galaxies**

NASA/CHRIS GUNN

## Massive reductions

The reason Steinhardt wanted to examine Labbé's galaxies is that the initial mass function astronomers universally apply is derived from the conditions in the Milky Way as it is today, whereas we know that star-forming gases would have been considerably hotter in the early universe. That would have inhibited the formation of low-mass stars, changing the initial mass function, the result of which would be a reduction of the mass of any given galaxy as a whole.

Sure enough, when he included such factors in his calculations, Steinhardt found that the masses of early galaxies decreased significantly. "We get the masses to come down for some of Labbé's galaxies by between a factor of 10 and 100," he says. The upshot is clear: "You might be able to still make them from the [dark matter] haloes that you can get under lambda-CDM."

That sounds a lot like another escape for cosmology-as-usual. But lambda-CDM isn't yet in the clear because Clara Giménez-Arteaga, a PhD student also at the Cosmic Dawn Centre, has performed another analysis of other early galaxies spotted by JWST – not the six Labbé had looked at – and got a very different result.

She was able to take an alternative approach to estimating the mass of young galaxies thanks to JWST's unprecedented optics, which can resolve even these far-off star clusters into collections of pixels – rather than single pixels containing less detail. That means you can estimate the number of stars and their masses in each pixel, then add them up to compare them with the value from the overall luminosity approach that Labbé used. "Thinking about this beforehand, I thought I should get about the same answer," says Giménez-Arteaga. What she found, however, was surprising: each of the

NASA/ESA/M. ROBBERTO/HUBBLE SPACE TELESCOPE ORION TREASURY PROJECT TEAM

**A Hubble Space Telescope image of a star-forming cloud of gas and dust**

galaxies she looked at was between three and 10 times heavier than previously thought.

The reason is that, in effect, treating each galaxy as a single unresolved pixel, rather than as a collection of pixels, hides the fact that star formation may not be taking place uniformly across the galaxy. The unresolved method causes brighter, newer stars to outshine dimmer, older stars, masking them from view and lowering the estimated mass, says Giménez-Arteaga. By treating each individual pixel as its own region, astronomers can see the vast number of long-lived, low-mass stars that have been created in previous rounds of star formation. "The physical mechanism that makes this happen can only increase the resolved mass," she says.

Giménez-Arteaga is yet to apply this method to the galaxies Labbé analysed, but given that the technique has been shown to increase the calculated mass of similar early galaxies, it would almost certainly do the same for the six in question – and would therefore intensify the contradiction with lambda-CDM.

Clearly, cosmologists need to get the true measure of these suspicious galaxies. The fate of the universe, or at least our understanding of it, depends on the answer. The good news is that, unlike the Hubble tension, a case that seems set to rumble on, we can expect definitive answers in the not-too-distant future.

Almost all the analyses done so far rely on images of the galaxies, which require astronomers to estimate a number of quantities such as age, distance and mass. But to accurately pin these down, you need spectra – where the collected light from an object is split into its constituent wavelengths for more detailed analysis. This is the next step in the process and, fortunately, is precisely what JWST was made for.

Unlike its predecessor, the Hubble Space Telescope, JWST is designed to capture light from the really distant universe, which has been dramatically stretched into the infrared region by the expansion of the universe. "JWST offers, for the first time, good quality spectroscopy covering the crucial wavelength range," says Andrew Bunker at the University of Oxford, who is a member of JWST's near-infrared spectroscopy instrument team.

With infrared spectroscopy, we can determine accurate distances and ages for the galaxies. Assuming that each galaxy is confirmed to be at the distance currently estimated – as most astronomers seem to confidently expect – spectroscopy will also allow us to test Steinhardt's ideas by investigating the temperature of the interstellar medium at each galaxy.

> "THE FATE OF THE UNIVERSE, OR AT LEAST OUR UNDERSTANDING OF IT, DEPENDS ON THE ANSWER"

As a proof of concept, Bunker and his collaborators recently released a spectrum of a very distant galaxy that had showed as a faint red dot in earlier Hubble data and was earmarked for further investigation. The results exceeded anything he had dreamed of. "We never thought we'd get such a beautiful spectrum," he says.

The upshot is that the galaxy, which is only about 700 million years old, appears to have experienced a short yet intense burst of star formation, followed by a rapid slowdown about 10 to 20 million years before the time of observation. Particularly interesting, says Bunker, is that the mass they calculated came in at around 200 times smaller than the Labbé sample.

Bunker says this isn't a direct refutation of the idea that those six galaxies could break cosmology, because the galaxies he analysed are in a different part of the sky. "It's possible lambda-CDM is broken, but the jury is out until we have the spectroscopy," he says.

So, the plot continues to thicken. For now, lambda-CDM has a stay of execution. But even if it survives this current crisis, it will face the chop at some point, says Steinhardt. "Lambda-CDM is a placeholder," he adds, meaning that until we understand the true nature of dark matter and dark energy, we are simply using the most generic examples of both in the model. In that context, it is perhaps surprising that such a simple model has been able to explain the entire universe for so long.

And yet it seems clear, at this stage, that JWST's ability to peer into the furthest reaches of the cosmos means it is going to keep finding things that put lambda-CDM under pressure. "It has already been a game changer," says Bunker. "We're now routinely getting high-quality spectra for which we can infer the properties of galaxies just a few hundred million years after the big bang." ▮

Stuart Clark is an astronomy journalist based in London. His latest book is *Beneath the Night*

# Outsider information

A few languages are unlike any of the other tongues in use today. They hold clues to the rules of language and even our experience of reality, finds **Andrea Valentino**

LAST February, amid the fjords of southern Chile, an elderly woman died – and a language fell silent. Cristina Calderón, a much-loved 93-year-old, was the last known native speaker of Yaghan, which could at one time be heard across the Tierra del Fuego – the Land of Fire – that forms the jagged tip of South America. The loss of any tongue is a tragedy, but Yaghan's extinction will be felt particularly keenly because this was no ordinary language. It was an "isolate": a language utterly distinct from those used anywhere else in the world.

Language isolates comprise about 200 of the estimated 7400 languages in use today and many are dangerously close to following Yaghan into oblivion. Estimates suggest that 30 per cent of all languages will have vanished by the end of the century. Isolates – some used by just a few hundred people – are particularly vulnerable.

But as their vulnerability has risen, so has an awareness that isolates can tell us a lot about human communication and cognition. In the past few years alone, they have offered us fresh insight into the interplay between cultural and linguistic evolution and provided support for a controversial hypothesis that links our understanding of reality with the language we use. "Each of these isolates is a… whole different window on the mind," says Lyle Campbell at the University of Hawai'i at Mānoa.

What's more, there is new hope that the research might also identify better strategies to help us save them from extinction.

Broadly told, the story of language is a family affair. The similarities between Danish and Dutch, or Swahili and Zulu, speak to a world where groups of languages are far from isolated. Instead,

FABIO BUONOCORE

they fall into roughly 140 common lineages.

Isolates are different. Instead of boasting gaggles of siblings, these languages stand totally apart. Probably the most evocative example is Basque, spoken by a community straddling the border of France and Spain. While *vin* is a favourite French tipple and Spaniards may enjoy a glass of *vino* with their dinner, the Basque equivalent is *ardoa*. And while farmers in Spain and France engage in *agricultura* or *agriculture*, their Basque counterparts prefer *nekazaritza*.

Having such unusual vocabulary compared with their surrounding languages can give isolates an air of the exotic, and foster a sense of pride and resilience among speakers. This may help explain why Basque has survived for millennia – a bronze tablet in the shape of a hand found in 2021 shows that an ancestor of modern Basque was being written down 2000 years ago, while Basque itself may have a history stretching back 5000 years or more.

Truth be told, however, isolates are more conventional than they might appear. Many were once members of larger families, but have been left isolated because those other languages vanished – usually through a blend of cultural influences, conquest and simple luck. Ket, for instance, a language isolate of Siberia, was once part of the small Yeniseian language family. It is now alone, potentially in part because of the spread of the Russian language following Russia's conquest of Siberia between the 16th and 18th centuries.

But, paradoxically, it is precisely because isolates are relatively conventional that they are so linguistically valuable. Each is a unique experiment that can cast new light on the solutions people have found for effective communication.

"There's so much diversity in how humans construct a cognitive world with their languages," says Anna Belew at the University of Hawai'i at Mānoa, who is also programme manager at the Endangered Languages Project. "And isolates, just by virtue of not having sister languages, tend to hold fairly unique ways of encoding the world."

Decode them and we gain a richer understanding of the rules of language. Kutenai, for instance, is an isolate spoken by the Kutenai people, an Indigenous community straddling the US-Canada border. It is one of the few languages in the world with a grammatical "fourth person", making it possible to fully clarify the meaning in phrases like "he held his hat". Kusunda, spoken in Nepal, lies at the opposite extreme. It is missing some of the grammatical features found in most languages, such as words like "no".

Isolates are also challenging assumptions about the fundamentals of languages and language evolution – as revealed by Al-Sayyid Bedouin Sign Language (ABSL).

Used by a Bedouin community living in Israel's Negev desert, ABSL arose in the first half of the 20th century, improving communication in a population where, through quirks of genetics and social

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"Each of these language isolates is a whole different window on the mind"

organisation, the rate of deafness is 50 times the global average. But what really makes ABSL special is how its words are formulated. Practically all languages rely on what is known as duality of patterning, whereby users combine a relatively small number of meaningless sounds or gestures to make a rich and extensive vocabulary. For example, essentially all of the words in the English language are constructed from a few dozen fundamental sounds, each represented by one or more letters of the alphabet.

The alternative – a language in which every word is unique and can't be broken into smaller, repeatable units – would be bewilderingly complex. In such a hypothetical spoken language, it might require people to remember that a certain timbre of hiss means breakfast, while mild squawking means bathroom. Yet that is precisely what ABSL does. Unlike all spoken languages, and indeed other sign languages, users must memorise a new and distinct gesture for every word they want to express. ABSL shows that duality of patterning isn't the universal feature of language we assumed it to be, and it also offers us clues as to why.

In a 2021 study, Simon Kirby at the University of Edinburgh and Monica Tamariz at Heriot-Watt University, both in the UK, compared ABSL to an unrelated but similarly young sign language – Israeli Sign Language – which does exhibit duality of patterning. They noted that Israeli Sign Language, like many formal sign languages, is usually learned by groups of students in schools. The two researchers reasoned that students interacting informally with one another – in the playground, for instance – would find and use linguistic features such as duality of patterning, because all students of a new language tend towards simplification. As other students adopt these simplifications, they take root and ultimately spread through the community.

## Child talk

New ABSL learners, on the other hand, typically pick it up through exposure to the language of elders. The learners may still come up with innovative ways to simplify the language. But older signers are unlikely to adopt what they might perceive as child talk. The result is that simplifications don't spread, and the language remains complex.

Kirby and Tamariz tested this idea with a simple computer simulation, containing a four-word "language" being used by a small, artificial population. If hypothetical students were taught by the oldest members of the population, who themselves were expert language users, it took more than 50 generations for duality of patterning to emerge. If, however, learners were taught by a younger member who was still picking up the language, duality of patterning emerged in just four generations.

REUTERS/DAVID MERCADO

The work suggests that language evolution can be shaped to a striking degree by the structure of a particular society. More specifically, Tamariz says the research identifies new learners as a powerful force in shaping languages.

One of the other big questions linguists are grappling with is the interplay between language and cognition. Some researchers argue that the way we communicate influences our perception of the world and our understanding of abstract concepts such as numbers, an idea known as the Sapir-Whorf hypothesis. This controversial idea has its critics, but language isolates might provide crucial evidence in its favour.

The speakers of one isolate in particular often feature whenever linguists debate the Sapir-Whorf hypothesis. The Pirahã people, an Indigenous group living in northern Brazil, are famous among researchers for speaking a language – also called Pirahã – that some research suggests has no words for numbers. What's more, studies suggest that Pirahã speakers struggle to count, implying that words for numbers are indeed necessary to do maths.

But there is a problem with that conclusion, according to Benjamin Pitt at the University of California, Berkeley. Pitt says that researchers have "implicitly or explicitly" compared the Pirahã speakers' understanding of numbers with the number knowledge of people in higher-income countries. He says this is hardly a fair comparison, given that the way of life in a country like the US is

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**Cristina Calderón was the last speaker of Yaghan**

**The Chimané people have provided insights into the power of number words**

## Tongues in trouble

**Pello Salaburu at the University of the Basque Country describes language isolates as "black swans" – outliers that force scholars to challenge their preconceptions around cognition (see main story). But many isolates may soon vanish.**

**Al-Sayyid Bedouin Sign Language was recently classified as "definitely endangered" by researchers at the University of Central Lancashire, UK, working with UNESCO and the Foundation for Endangered Languages. It is thought to be used by no more than 4000 people in Israel. Chimané, with about 4800 speakers in Bolivia, is considered "vulnerable" by the Endangered Languages Project. Some isolates are at even greater risk: Kusunda, from Nepal, has a single surviving fluent speaker.**

**Other isolates have more speakers, but are still threatened – and their disappearance would result in the loss of fascinating linguistic features. Purépecha, for instance, has about 117,000 speakers in Mexico and boasts a distinctive numerical system. While it is common for languages to make some numbers above 10 by combining two earlier numbers, such as "twenty-one", Purépecha is unusual in using this approach for the numbers 7, 8 and 9 too.**

wildly different from that in the Amazon.

To really understand whether number words are necessary for counting, Pitt says we need to compare people who either do or don't know such words, but who still share a common culture. Elsewhere in the Amazon, Pitt and his colleagues found an Indigenous community of such people.

The Chimané people live in lowland Bolivia. Their language, Chimané, is another isolate and it does contain number words. Crucially, however, knowledge of those words varies across the society: some Chimané can count indefinitely, while others stumble at 10 or 12.

Pitt and his colleagues worked with 30 Chimané people, only 15 of whom were confident counters, and asked them to complete some counting tasks. For instance, volunteers were presented with a row of pebbles and asked to produce their own row containing the same number of pebbles. Most volunteers could do so reasonably accurately when told to make their row parallel to the row already on the table – perhaps, says Pitt, because they could simply match up the pebbles without having to count them.

However, when told to arrange their row of pebbles perpendicular to the row already on the table – which does require counting – Pitt and his colleagues saw a clear pattern. In their study, published last year, performance in the test hinged on knowledge of number words. Though everyone managed to demonstrate a grasp of numbers up to about 4 – which is thought to be an ability that is widespread among non-human animals too – volunteers could thereafter only accurately reproduce perpendicular rows as far as their verbal knowledge of numbers carried them. To give a theoretical example, if someone knew the numbers up to 15, they could only make a row of pebbles that long.

In the past, some researchers have argued that people can use a range of different cognitive tools to count, downplaying the importance of language. The research by Pitt and his colleagues suggests this idea is wrong and language is crucial. Especially in the realm of numbers much larger than 4, Pitt says Chimané shows that language sometimes offers people "new conceptual abilities" – which may otherwise be unavailable to them.

But whatever gems they can offer linguists, isolates are, by definition, vulnerable (see "Tongues in trouble", above). Unlike other languages, whose insights may be preserved in related tongues, isolates have no family to fall back on. "We really need to get information on the isolates," says Campbell, "because if we lose them, that information is gone forever."

Yet it is just possible that the very act of studying isolates might improve our ability to save them. Ane Ortega-Etcheverry at the Begoñako Andra Mari Teacher Training University College, Spain, knows from experience that isolates can survive against the odds. A child of Francisco Franco's dictatorship – which, for decades, waged a war against Spain's minority tongues – she had scant opportunity to learn Basque while growing up. But after embracing her ancestral tongue as an adult, Ortega-Etcheverry devoted years to exploring why it is so resilient to extinction.

In a 2014 study, she and her colleagues interviewed a range of non-native Basque learners, uncovering what she calls a "continuum" of attitudes among participants. At one end were so-called *euskaldunberri*, or new Basque speakers, including those being taught the language at school. At the other end were *euskaldun*, or proficient Basque speakers.

Ortega-Etcheverry and her colleagues were surprised to find that *euskaldunberri* becoming fully-fledged *euskaldun* had less to do with technical proficiency and more to do with culture. To put it another way, being taught to speak Basque fluently is less important than having family and friends familiar enough with the language to use it in conversation. Some felt that the formal Basque they studied in school made them less *euskaldun* than learning a rugged local dialect.

Ortega-Etcheverry is already spreading the word from her research. She is now working with speakers of Nasa Yuwe, an isolate from Colombia that, with about 60,000 speakers according to some estimates, is classified as vulnerable. "School is not enough," says Ortega-Etcheverry, arguing that if endangered languages are to thrive, activists need to create a welcoming cultural atmosphere.

Get the strategy right and Ortega-Etcheverry thinks we can turn the tide and help vulnerable language isolates survive. It might just ensure that when older community members like Cristina Calderón die, the languages they speak live on. ■

Andrea Valentino is a journalist based in New York

# The back pages

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## Debunking gardening myths

# Hold the coffee

We are often told to add used coffee grounds to garden soil to perk up plants. But the science doesn't support this, says **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, he shares his tiny London flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek

WANDERING around an achingly cool San Francisco coffee shop a few years ago, I was fascinated to see huge, open-topped barrels filled with used coffee grounds and a sign saying they were free for customers to scoop into recycled bags and take home to perk up their plants. I realised that we had reached peak hipster.

Indeed, the claim that coffee waste dramatically boosts plant growth has been a staple of organic gardening books since at least the 1970s, and seems to be seeing a modern renaissance. Proponents everywhere wax lyrical about how the spent grounds are not only rich in nitrogen – a key plant nutrient – but can help lower the pH of garden soils for species whose roots require acidic conditions, like blueberries. It all sounds like such a brilliant idea: upcycling industrial waste into free, organic fertiliser. It is just a shame that in reality it is probably doing the exact opposite. Let me explain…

Coffee grounds, even after brewing, are still a rich source of caffeine. This compound seems to be produced by coffee bushes – at least in part – as a herbicide to suppress the growth of smaller competing plants. The phenomenon is called allelopathy and is a strategy loads of plants have evolved to help reduce the competition for light, space, water and nutrients around them.

DGLIMAGES/ALAMY

Leaching out of the grounds, the highly soluble caffeine percolates through the soil and has been repeatedly shown to severely stunt the growth of small, neighbouring plants' roots and slash the rate of seed germination, even at relatively tiny concentrations. Not exactly what the plantfluencers of social media promise.

The weirdest thing about how often this tip is recommended is that we have known about the allelopathic potential of caffeine in coffee plants for decades. The first paper I could find on this was from 1980, and its conclusions have been echoed by study after study. So effective is caffeine at suppressing plant growth, it has been investigated as a potential novel herbicide for agricultural use, both in the form of direct application of coffee grounds on farms in Brazil and even tea leaves (which also contain caffeine) on plantations in Vietnam.

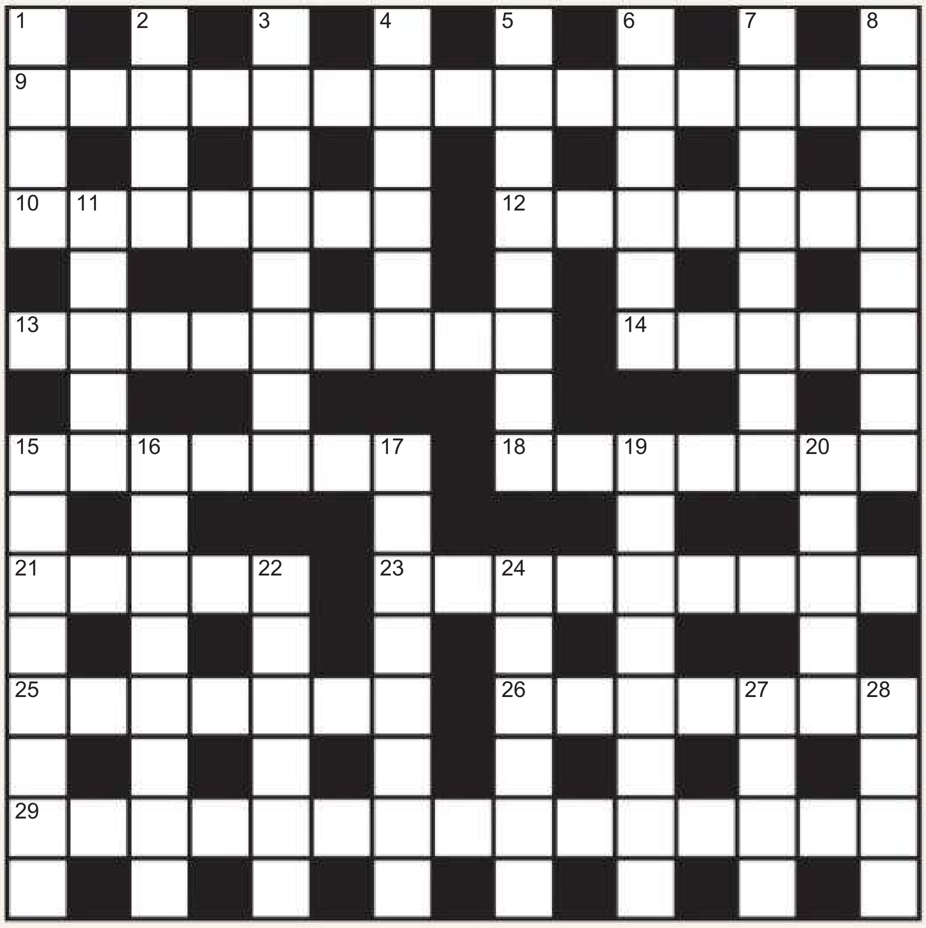
This effect is so pronounced that over years of intensive cultivation, the accumulated caffeine in the soil of long-established coffee farms can reach levels where it doesn't just hamper the growth of small weed seedlings, but even the mature coffee bushes. Studies have been conducted to see if underplanting coffee with more resistant herbs, like sage and oregano, could help reduce the caffeine contamination in the soil by drawing the compound up through their roots, while providing farmers with an extra crop to harvest. I wonder if the world is ready for caffeinated herbs. But that's another matter. ■

*Debunking gardening myths appears monthly*

**Next week**
The science of cooking

**These articles are posted each week at newscientist.com/maker**

## Quick crossword #135 *Set by Richard Smyth*



**Scribble zone**

Answers and the next cryptic crossword next week

**ACROSS**
**9** Necker cube, for example (7,8)
**10** Outer layer of a tree in the genus *Ulmus* (3,4)
**12** Marine sirenian (7)
**13** James ___, English doctor who first described "the shaking palsy" (9)
**14** Eukaryotic microorganism (5)
**15** Causal sequence of processes (or waterfalls) (7)
**18** Crop such as sesame or sunflower (7)
**21** Leak blood or other fluid (5)
**23** Figure placed above the denominator in a fraction (9)
**25** Earth, wind, fire or water, classically (7)
**26** Clawed crustacean (7)
**29** Eating disorder (8,7)

**DOWN**
**1** Burrowing vermivore (4)
**2** Minuscule component particle (4)
**3** Pain in the lower back and leg (8)
**4** Lobes of a whale's tail (6)
**5** Long-legged pink wading bird (8)
**6** Peritonsillar abscess (6)
**7** Liquid that has passed through a filter (8)
**8** Not tried; novel (8)
**11** Andean camelid (5)
**15** Aerial lift; ropeway (5,3)
**16** Supporting bone structure (8)
**17** Albert ___, German patent examiner (8)
**19** Australian bird that may be Albert's or superb (8)
**20** Wear away (5)
**22** Rudolf ___, engine inventor (6)
**24** Fruits of a plant in the family Cucurbitaceae (6)
**27** Object put to practical use (4)
**28** Thoroughfare; route (4)

**Our crosswords are now solvable online**
newscientist.com/crosswords

## Quick quiz #206

*set by Bethan Ackerley*

**1** What was the third nation to launch a space satellite on its own rocket, after the US and the USSR?

**2** Lipases, peptidases and glycosidases all belong to which class of enzyme?

**3** Ploidy refers to the number of complete sets of what in a cell?

**4** The element ytterbium is named after a town in which country?

**5** Which of these dinosaur groups was primarily carnivorous: hadrosaurs, ankylosaurs or theropods?

*Answers on page 47*

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## Headscratcher

*set by Mary Ellis*

### #226 On reflection

**Hannah handed me a piece of paper with the following string of letters.**

**XTXUXVHXUXOXUXHVXUXTX**

**"Each letter stands for another one," said Hannah.**

**"Ooh, a substitution cipher!" I thought. But I was stumped.**

**"Is this just one word?" I asked.**

**"No, I've removed all the spaces," said Hannah. "I think if I told you where the first space is, you might get the answer very quickly. You'll probably recognise it."**

**I happened to look at it in the mirror. "Wow, what are the chances of that?"**

**"Well, it isn't entirely a coincidence," said Hannah.**

**"Aha!" I said, though I was still none the wiser. Can you decipher the text for me?**

*Solution next week*

## Lined up

**Will there ever be a time when all the planets of our solar system line up in a row, one behind the other, as seen from Earth?**

***Ian Christie***
*Melbourne, Australia*
The short answer is no. The long answer is: Assuming that we don't need this alignment to include the sun, the limiting factor is that all of the planets must align with Mercury. We will also ignore the possibility of the sun obscuring the view of some of the planets.

This gives us two chances for each orbital period of each of the other seven planets. To a first approximation, this will occur once every $1.2 \times 10^{19}$ years. This time is just the product of all of the half-orbital periods of the seven planets (with a little rounding off and ignoring any long-term changes in orbits, not to mention possible cosmological events such as the big rip, when the universe may tear itself apart).

My workplace, the Victorian Space Science Education Centre, has a primary school programme that helps students understand that the pictures in educational texts and websites that show the planets all lined up are misleading, with wrong relative diameters, wrong relative spacing and an alignment that never happens.

> **"By the time all the planets of our solar system line up, the sun would have expanded and swallowed Mercury and Venus"**

***David Craig***
*Edinburgh, UK*
Mutual alignments, when one planet overlies another as seen from Earth, occur about once every 30 years. A rough calculation shows that an alignment of all seven planets as seen from Earth is therefore likely to occur once in 22 billion years, i.e. longer than the 14-billion-year age of the universe.

CATHERINE FALLS COMMERCIAL/GETTY IMAGES

Most animals with a backbone also have a tail, so why don't frogs and apes?

### This week's new questions

**Telling tails** **Why do almost all vertebrates have tails, even when they don't seem useful, but apes and frogs don't?** ***Will Stites****, Stevens Point, Wisconsin, US*

**Out of time** **If time started at the big bang, is it ever likely to come to a halt?** ***John Howes****, Cardiff, UK*

A conjunction of the five planets visible to the naked eye – when they align within 10 degrees of each other in the sky – happens roughly every 500 years. The last was on 17 September 1186 and the next will be on 8 September 2040. Unless it is cloudy.

***Eric Kvaalen***
*Les Essarts-le-Roi, France*
It depends what you mean by lining up. They will never line up exactly, unless there is some very fine tuning, but they can all be within a certain angle.

We can estimate how often Venus, Mars, Jupiter and Saturn will be within 1 degree of Mercury. This will happen around the time of a "great conjunction", when Jupiter and Saturn line up, more or less.

Great conjunctions occur on average every 19.86 years and are sometimes triple, in which the two planets line up three times within a period of several months. When Jupiter and Saturn align, it can be anywhere from 0 to 360 degrees away from Mercury, but in every great conjunction one alignment occurs within about 80 degrees of the sun. Mercury stays within 23 degrees of the sun, so the probability of that alignment of Jupiter and Saturn being less than 1 degree from Mercury is about 1 in 80 (1.25 per cent).

Venus stays within 46 degrees of the sun, and the probability of it being within 1 degree of Mercury at the moment in question is about 1.6 per cent. Finally, the probability of Mars being in that window is about 0.9 per cent. So the probability of all four being within 1 degree of Mercury is about 0.00018 per cent. This would occur on average once in 10 or 11 million years.

This is the frequency for Venus, Mars, Jupiter and Saturn being within 1 degree of Mercury when Jupiter and Saturn line up exactly. However, the four might be within 1 degree of Mercury a couple of days before or after the exact alignment of Jupiter and Saturn, so this pattern would occur more often than once in 10 million years.

All this only considers how far apart the planets are in the east-west direction. It doesn't account for how far north or south they are relative to each other, nor does it take Uranus and Neptune into consideration, each of which would increase the time interval for all planets to be within 1 degree of Mercury by a factor of 180.

By that time, the sun would have expanded and swallowed up Mercury and Venus.

## Wheely dirty

**Why are the front wheels of my car always much dirtier than the rear ones?**

***Guy Cox***
*Sydney, Australia*
I suppose Rob Janes [who posed this question] normally drives forwards, so the front wheels of his car encounter all the muck and slush on the road first and either accumulate it or swish it out of the way. We could plan a scientific experiment here: would he be willing to drive only in reverse for a month to see what happens to his wheels?

***David Muir***
*Edinburgh, UK*
The vast majority of particulate pollution from modern cars comes from friction between the tyres and the road surface, as well as from the brakes within the wheels. The amount of polluting particles produced depends on

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## Tom Gauld
*for New Scientist*

USING A DISGUISE, THE PROFESSOR IS ABLE TO LIVE UNDETECTED AMONGST THE TREES, GAINING INSIGHTS UNAVAILABLE TO LESS-COMMITTED BOTANISTS.

vehicle weight, driving style and the material composition of the brakes, tyres and roads.

When drivers brake, their weight is thrown forwards, hence seatbelts. The weight of a braking vehicle is also projected forwards, so the job of slowing the vehicle lands mainly on the front brakes. This causes greater wear on these than on the back brakes, and thus more particle pollution from within the front wheels than the back, which makes the front wheels dirtier.

***Harald Mandl***
*via email*
The front wheels of cars usually have disc brakes (where a calliper squeezes pads against a disc to create friction). The abrasion of these disc brakes is deposited on the rims. Rear wheels typically have drum brakes (where a cylindrical drum that surrounds the brake shoes is attached to the wheel). Much less abrasion can escape from drum brakes because they are closed, while disc brakes are open systems.

**“We could plan a scientific experiment here: driving only in reverse for a month to see what happens to the wheels”**

If disc brakes are also mounted on the rear wheels, then there is much less abrasion here than there is in the front, because the mass of the vehicle shifts to the front when braking and therefore the front brakes are much more heavily loaded. That is why disc brakes at the rear are much smaller than those at the front.

***Paul Gibbons***
*Banstead, Surrey, UK*
This is because the front brakes work between two and 10 times harder than the rear ones.

The rear braking limit is set to the point where the rear wheels lock up. This happens at a much lower level than the front wheels due to forward-shifting weight while braking. So the front brakes grind away five times more brake pad material and this gets deposited on the front wheels.

***Martin van Raay***
*Culemborg, the Netherlands*
There are special products to clean brake dust off aluminium alloy wheels. If this isn’t removed regularly, it will damage the surface of alloy wheels as the brake dust etches and stains the surface. If this damage has occurred, then only a more expensive treatment by a specialist will restore the wheels to their original splendour.

## Octopus tech

**If an intelligent marine species like the octopus evolved to live on land, what is the likelihood it would develop technology? (continued)**

***Mark Inwood***
*Reigate, Surrey, UK*
Because octopuses are so short-lived, they would need to evolve writing to pass information between generations in order to develop technology.

They already have the ink! ▮

## Answers

### Quick quiz #206
*Answers*

**1** France, with Astérix in 1965
**2** Hydrolases
**3** Chromosomes
**4** Sweden
**5** Theropods

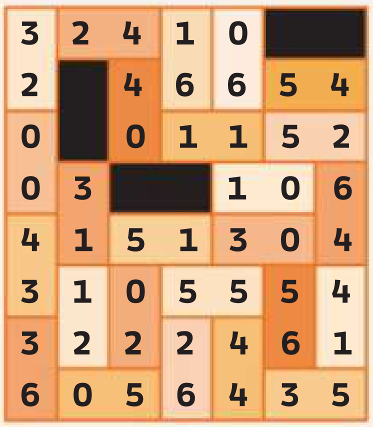
### Cryptic crossword #111 *Answers*

**ACROSS 1** Bloom, **4** Captcha, **8** Astronaut, **9** Mob, **10** Coil, **11** Detonate, **13** Behold, **14** Geyser, **17** Delivery, **18** Gold, **20** Gum, **21** Nightmare, **22** Tussaud, **23** Dread

**DOWN 1** Bear cub, **2** Ostrich plumes, **3** Moog, **4** Crater, **5** Pathogen, **6** Compassionate, **7** Amble, **12** Slovenia, **15** Red lead, **16** Frigid, **17** Digit, **19** Stud

### #225 Dominoku
*Solution*

Counting up, we are short of two 2s, two 3s and two 6s. The top left corner must contain a 3-2 domino, so that combination isn’t missing. This means the missing dominoes must be 2-2, 3-3 and 6-6. Hence, we can break up the 2-2-2 in the seventh row and the 3-3 and 3-2 in the bottom left, meaning 6-3 must be there. The only 2-1 on the grid is to the right of it, which forces 0-5 on the bottom row. Continuing from there leads to the solution:



| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 2 | 4 | 1 | 0 | | |
| 2 | | 4 | 6 | 6 | 5 | 4 |
| 0 | | 0 | 1 | 1 | 5 | 2 |
| 0 | 3 | | | 1 | 0 | 6 |
| 4 | 1 | 5 | 1 | 3 | 0 | 4 |
| 3 | 1 | 0 | 5 | 5 | 5 | 4 |
| 3 | 2 | 2 | 2 | 4 | 6 | 1 |
| 6 | 0 | 5 | 6 | 4 | 3 | 5 |

## Power meringue

**Researchers in South Korea and the US have cooked up a recipe for meringue that you can then use to make electrical batteries.**

**Extract albumen from raw eggs, after removing the yolk and chalaza (the twisted strips that attach the yolk to the shell). Whisk with a hand mixer in a steel bowl. Wait 5 minutes. Gradually add an equal amount (by weight) of white sugar, whisking for 15 minutes to produce a porous albumen foam. Bake in a convection oven at 100°C (212°F) for 2 hours. Then bake in an argon-filled oven at 800°C (1472°F) for 2 hours more, before letting the meringue cool to room temperature.**

**That's the fun, kitchen-skills part of a study called "Meringue-derived hierarchically porous carbon as an efficient polysulfide regulator for lithium-sulfur batteries".**

**The researchers intimate, without resorting to plain language, that this meringue is intellectually delicious from a chemical engineering perspective. Writing in the *Journal of Industrial and Engineering Chemistry*, they say: "Li-S batteries with interlayers utilizing meringue-derived hierarchically porous carbon (MHPC) not only facilitated electrolyte penetration but also improved the transport of Li-ions."**

**This isn't the first research paper that discusses meringue and electrical devices. It is at least the second. A 2022 paper in *Modelling and Data Analysis* is called "On the experience of developing a mobile complex for recording the brain electrical activity on the meringue of dry electrode technology". The word meringue appears only in the title. It makes no mention of eggs, sugar or a whisk. This meringue has yet to reveal its secrets to the world.**

## Public relations equation

"It will cost up to $21.5 billion to clean up California's oil sites. The industry won't make enough money to pay for it", reads the headline of a report by news site *ProPublica*.

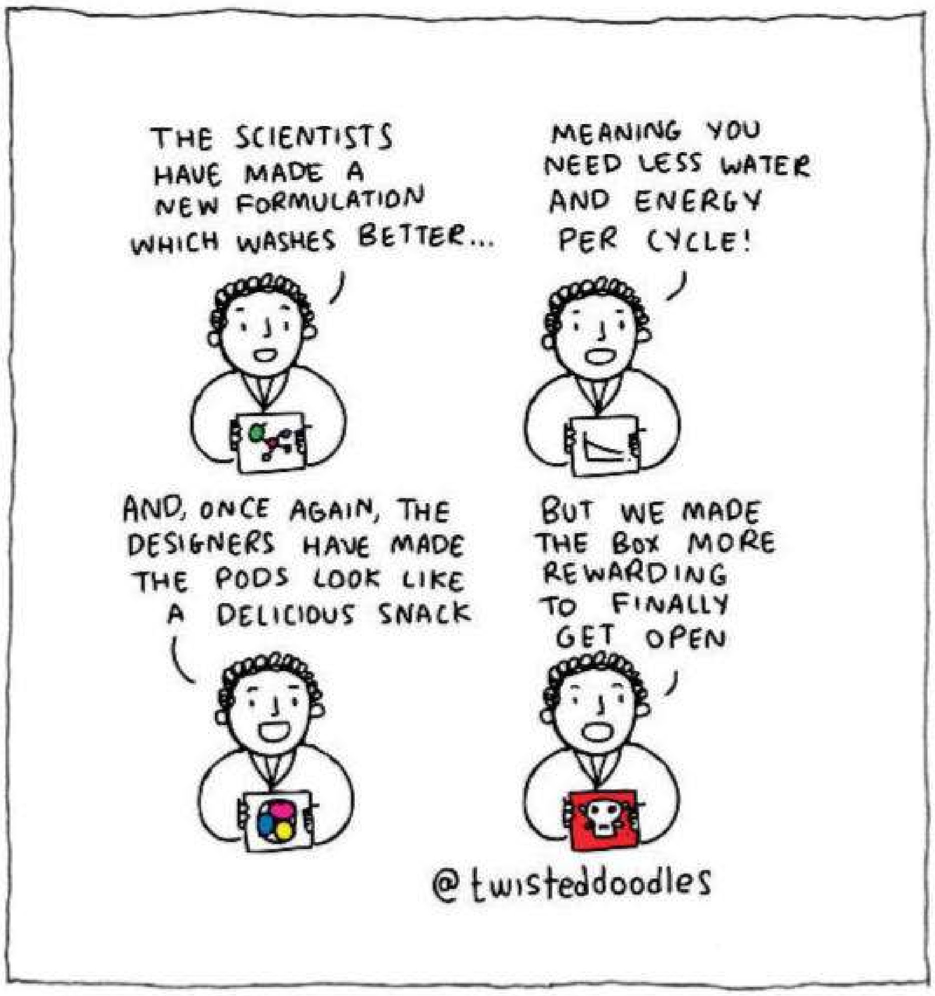
Such revelations – of things costing much more than the public had been told – can bring a knowing smile to anyone who loves equations. Here's why. It is a reminder, first, that in the field of economics (like everywhere else), what you choose to leave out of your equations matters and, second, that it might be a long time before people realise what is missing.

The art – the engineering, really – of how to remove things from your equations is called public relations. In 2016, Diana Ingenhoff at the University of Fribourg in Switzerland and Alexander Buhmann at BI Norwegian Business School showed readers of *Public Relations Review* how to properly cook up or boil down equations, in their paper "Advancing PR measurement and evaluation: Demonstrating the properties and assessment of variance-based structural equation models using an example study on corporate reputation".

Ingenhoff and Buhmann stated what may be an essential truth about the abstrusities of their craft. (Yes, abstrusities. Public relations is peppered with intellectual challenges that might stun a string theorist or a neuro-philosopher.) They said: "Measuring and evaluating outcomes (such as image, reputation, trustworthiness, or legitimacy) is a demanding task since these target constructs are no manifest phenomena, but rather complex intangibles that have to be defined, specified and operationalized carefully to produce meaningful results."

If that strikes you as too complex to follow or swallow, muse instead over a simple thought expressed by researcher Yungwook Kim, then at Illinois State University, in the 2001 paper "Measuring the economic value of public relations". Kim said: "it is difficult to explain a complex reality with a single equation."

## Twisteddoodles *for New Scientist*


THE SCIENTISTS HAVE MADE A NEW FORMULATION WHICH WASHES BETTER...
MEANING YOU NEED LESS WATER AND ENERGY PER CYCLE!
AND, ONCE AGAIN, THE DESIGNERS HAVE MADE THE PODS LOOK LIKE A DELICIOUS SNACK
BUT WE MADE THE BOX MORE REWARDING TO FINALLY GET OPEN
@twisteddoodles

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## Falling off to sleep

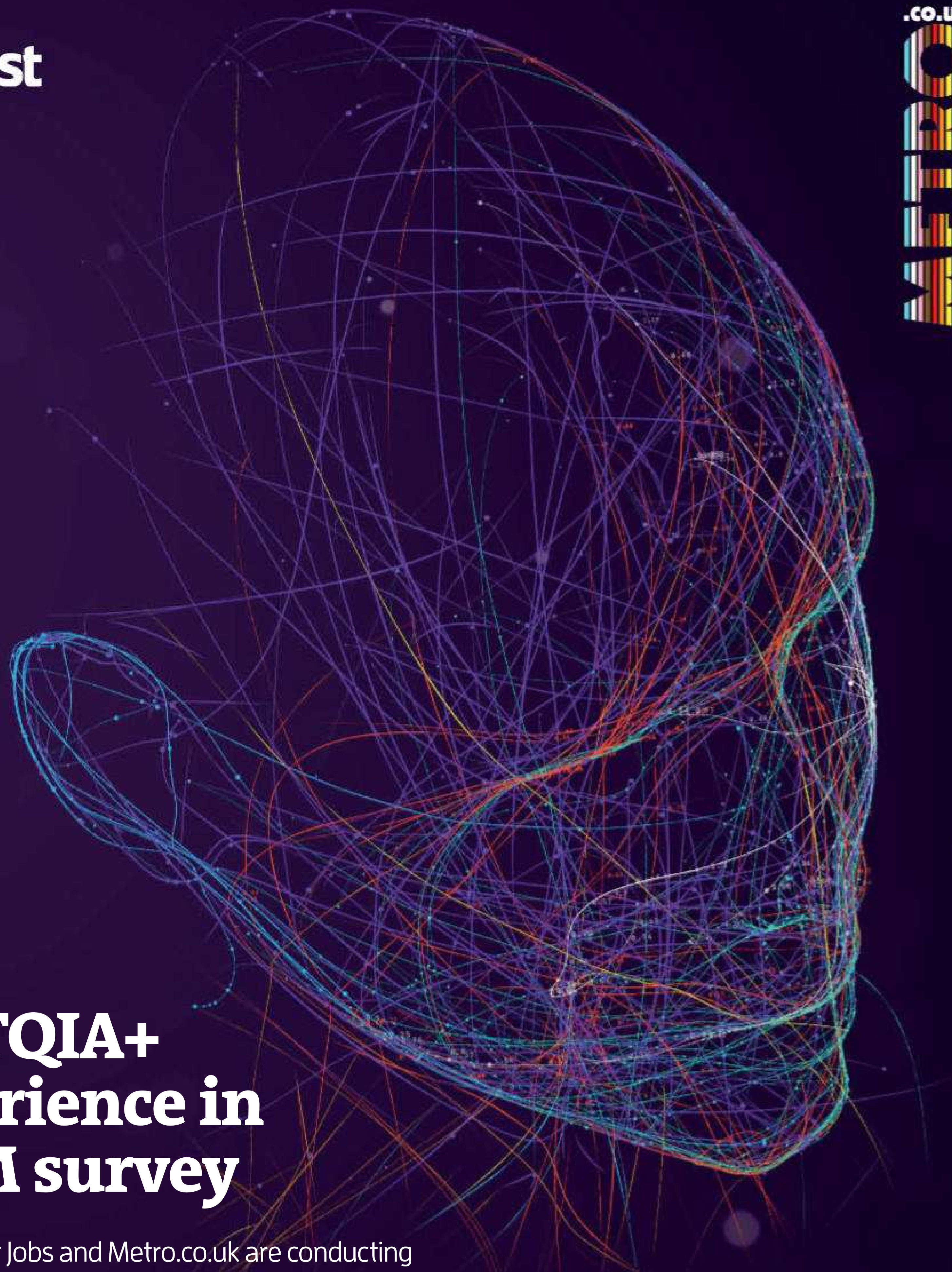
**Stephen Ferguson contributes a dangerously relaxing addition to Feedback's nascent catalogue of trivial superpowers.**

**He says: "I can fall asleep in any moving vehicle. While serving in the Falklands I found I could sleep in a Chinook helicopter which caused me to miss where I was supposed to get off, which in turn caused the pilot to have to turn around and take me back. The Loading Master was very angry with me and shouted that it cost £5K an hour to fly and I had just wasted £2K (this was in 1984). While working on the Isle of Man I found I could also fall asleep while riding a bicycle. And yes this did cause me to fall off – repeatedly. I fell into ditches, hedges and cycled into a farm gate."**

## Nap time

Gillian Metheringham reports another sleep-related trivial superpower. She says: "I am able to nap whenever I feel a wave of sleepiness overcoming me and then wake up after a defined number of minutes, feeling fully rested and ready to continue the day. The only requirement is for me to say the number of minutes (e.g. 10 minutes) aloud to myself first and look at a clock to orient myself. I admit that while I was still working, I would sometimes go into the women's loo and sit on the toilet lid for exactly 10 minutes, emerging bright-eyed well before anyone started looking for me. I have only actually tested this with 10, 15 and 20 minutes. I must say, while this superpower pales in comparison with those possessed by Marvel characters, it has been un-trivial in its usefulness to me over the years." ▮

*Marc Abrahams*



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